INSTRUMENTS AND CONTROL SYSTEMS

MAY 1960

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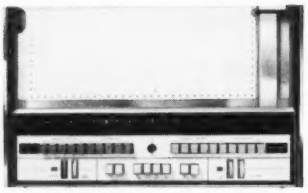
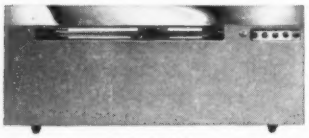
C-R Arbitrary-Function Generator 808

THIS PRINTING: 37,600

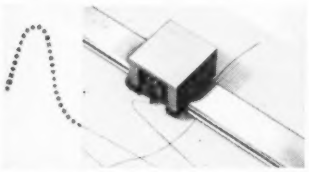
INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER



PUSH BUTTON PANEL controls operations rapidly, even at remote locations.

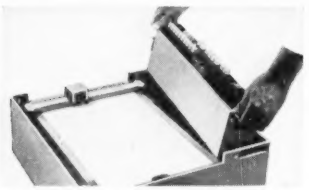


FLAT VACUUM PLATEN assures positive hold down of roll or sheet paper up to 12¼" width. Plot area, standard 10x15".

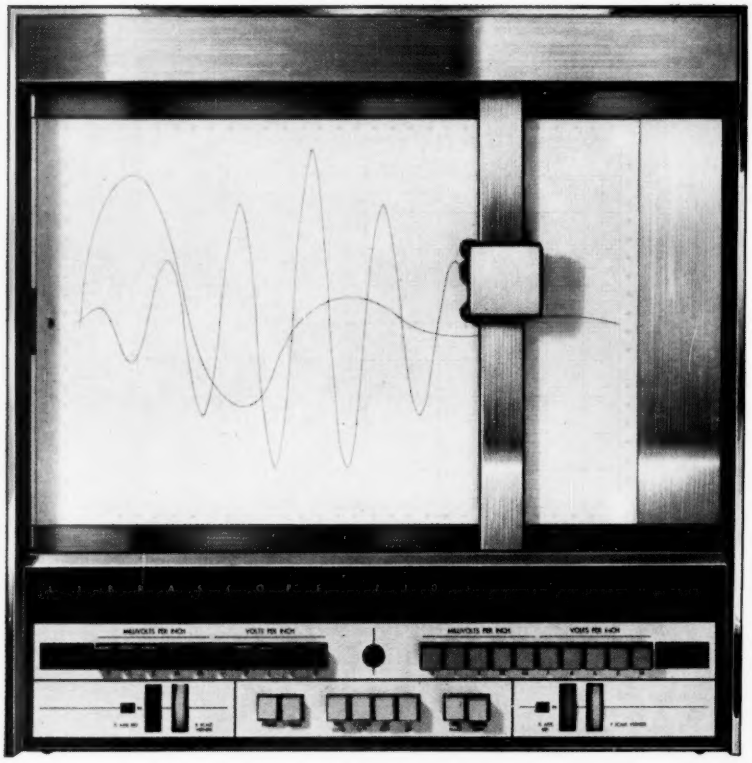


PRINTING FEATURES: Multiple symbol printing head—12 symbols...self contained ink supply.

Pen System—capillary action; splatter-proof. Point joiner available.



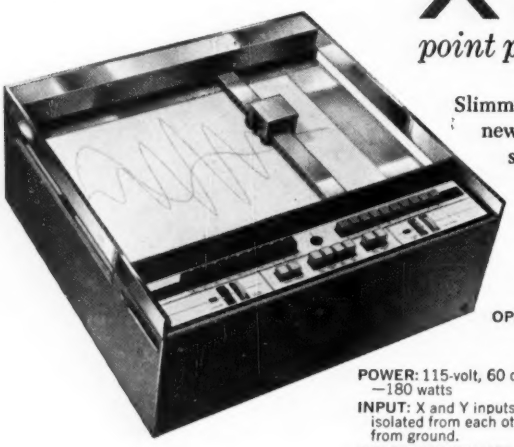
INTERCHANGEABLE MODULES add versatility...interchange with basic control section.



engineered for ease of operation...new

LIBRASCOPE X·Y PLOTTER

point plotting or continuous trace



Slimmer, flatter, push-button fast...Librascope's newest, most advanced plotter is the result of personally-conducted field research by Librascope engineers. Compact design permits rack mounting in groups, saves desk space. Many new conveniences have been added to answer *your* needs.

OPERATING INFORMATION

POWER: 115-volt, 60 cycle —180 watts

INPUT: X and Y inputs isolated from each other and from ground.

INPUT RESISTANCE: 2 megohms nominal on most scales. 1 megohm per volt on .5 millivolts per inch to .1 volts per inch scales.

INPUT SENSITIVITY: .5 millivolts per inch to 50 volts per inch with calibrated push button scales at .5, .1, 5, 10 and 50 millivolts per inch and .1, .5, 1, 5 and 10 volts per inch. Vernier controls permit continuous sensitivity adjustment between fixed scales, permitting full scale plotting for any sensitivity.

ACCURACY: Static .1%, dynamic .2% at 10" per second.

PLOTTER CALIBRATION ACCURACY: .05% on all scales.

SLEWING SPEED: 20" per second.

For full details — dimensions, applications, list of accessory equipment, call our Sales Engineering Department or send for illustrated brochure on Model 210, XY Plotter.

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

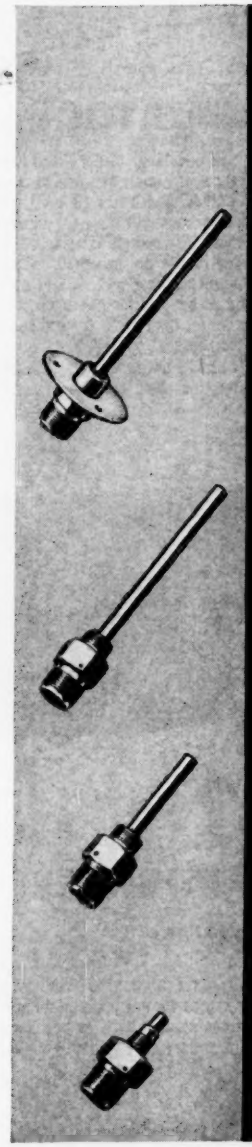
GPD LI 9-20

LIBRASCOPE division **GENERAL PRECISION, INC.** • 808 Western Ave., Glendale, California

CIRCLE 1 ON READER-SERVICE CARD

RESISTANCE *type* TEMPERATURE DETECTORS

By LEWIS



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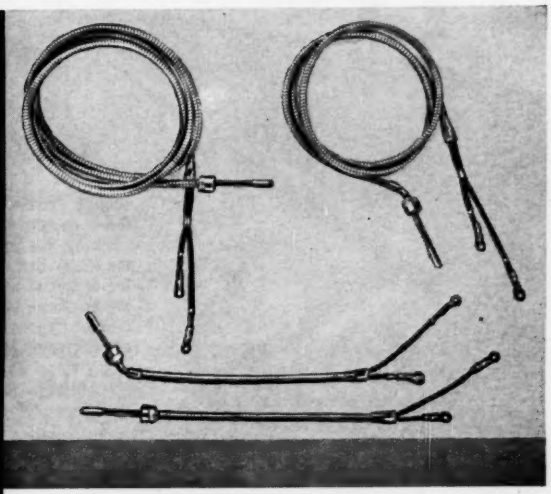
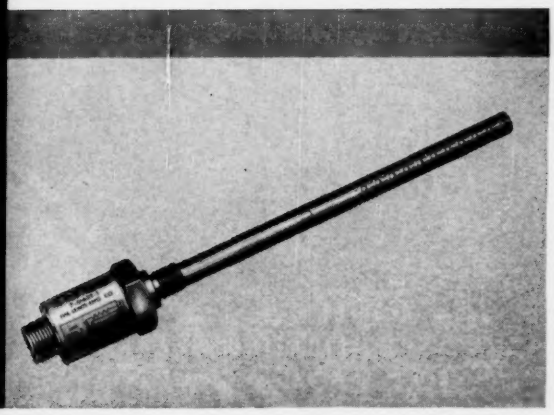
AIR

and other media to customer's specifications





FOR AIRCRAFT AND MISSILES

THE LEWIS ENGINEERING COMPANY

NAUGATUCK, CONNECTICUT

Specialists In Temperature Measurement

CIRCLE 2 ON READER-SERVICE CARD

A SENSITIVE RESEARCH

TRIPLE PLAY!

1. AC-DC WIDE RANGE CALIBRATOR

SRIC's versatile AC/DC Volt-Amp-Milliammeter "Self Checking" Model Thach is now offered in combination with a general purpose power supply for use as a convenient, economically priced, wide range instrument calibrator. The Model Thach has 19 overlapping full scale ranges of current and voltage. Operation is almost always at or near full scale for maximum accuracy. The power supply (Model Thach-PS) is a regulated source with its controls interlocked with the Model Thach. Power to the Thach is automatically shut off when ranges are switched, reducing the danger of accidently overloading the calibrator and/or the instrument under test. Output covers the full range of the Thach for DC and 60 cps. 50-2500 cps. can be plugged in for operation over a broader frequency range. Resolution of the power supply controls is better than .05% for any current and voltage range.

Any Model Thach with range combs. 1x or 3x is available for operation with the power supply. In addition, existing instruments in the field can be modernized for this same purpose at a small surcharge.

2. AC-DC LABORATORY STANDARD

The Model Thach can be used independently as a true RMS measuring instrument powered by any appropriate source. It checks its own accuracy against an internal standard cell, and is furnished completely self contained with a high sensitivity galvanometer. General specifications are as follows: Accuracy ± .2% F.S. (.1% at self-check points). Ranges 10/20/50/100/200/500 ma; 1/2/5 amps; 1/2/5/10/20/50/100/200/500/1000 v. Frequency range DC and 7 cps. to 4 kc. Sensitivity 100 ohms volt. Thermocouple D'Arsonval type. 100 division 6.3" hand drawn mirrored scale. Temperature compensated from 20°C. — 30°C. 1000% manually operated overload protection system. Independent of influence of stray magnetic fields. Diamond Pivoted with sapphire shock mounted jewels. Furnished with 1 or 2 thermocouples. Available in two combinations: 1x is self checking at full scale only: 3x is self checking at 5 cardinal points including full scale. Size 16⅜" x 10½" x 8¾" deep. Weight approx. 21 lbs.

Model THACH AND THACH-PS

3. AC-DC GENERAL PURPOSE POWER SUPPLY

The Model Thach-PS, while designed primarily for operation with the Model Thach, can be used independently as a power source for any appropriate application. It only has to be disconnected from the Model Thach to become an excellent general purpose switch controlled laboratory supply.

SPECIFICATIONS:

OUTPUT: DC or AC (60 cps normal; 50-2500 cps depending on input) **Voltage:** Delivers 0-120% at full load and a max. of 0-175% at no load. 1/2/5 v. at 300 ma.; 10/20/50 v. at 100 ma.; 100/200/500/1000 v. at 25 ma. **Current:** 0-5 amps. at 15 watts max. on low power, or 75 watts max. on high power.

INPUT: 90-135 v., 60 cps single phase, or 115 v. 50-2500 cps from a regulated source.

WAVEFORM: 60 cps distortion 2.5% total harmonic content plus line distortion.

RIPPLE: Varies from .5% at full voltage and low currents to a maximum of 2.5% for currents of 1 ampere or less. At currents above 1 ampere, ripple can always be 3% or less if series resistance is sufficient in external circuit and will be no worse than 7% for any possible operation.

RESOLUTION: .05% or better by means of coarse, medium and fine controls.

SIZE: 12¾" x 17" x 9" deep.

WEIGHT: Approx. 59 lbs.

S Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y.

CIRCLE 2 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

CLINICAL THERMOMETERS are heated by immersion in a stirred water bath in a National Bureau of Standards temperature standardization study. Story on page 770.

VOLUME 33
NUMBER 5

MAY
1960

EDITORIAL

Want An Overseas Instrumentation Job? 761
J. L. LOPEZ—guides to a successful and happy foreign assignment.

Creative Thinking 762
DICKEY DYER—top management must think of the possibilities of the future.

FEATURE ARTICLES

Serial Comparison By Symbolic Logic 766
ROBERT BROOKS—comparison for equality and inequality can be made using logic charts and gating packages.

Temperature Standards 770
R. E. WILSON—survey of NBS activities in temperature standardization and calibration.

Temperature Standards 775
A. G. McNISH—by taking a physical constant to define the temperature scale, we gained a great deal.

Cutting Holes In Sheet Metal 777
R. L. FARR—device used to cut clean holes to accommodate gages.

Temperature Calibration Survey 778
RESULTS of Aerospace Industries Association questions on calibration in temperature measurements.

The Temperature Standards Lab 782
CHARLES E. WHITE—instruments used and measurement accuracy capabilities of an advanced facility.

Temperature Standards At GE 786
S. C. RICHARDSON—include fixed points at the melting, freezing and boiling temperatures of pure elements and compounds.

Resistance Temperature Detectors 790
VICTOR W. ROSE—of the three common non-radiation-type electrical temperature sensing devices available, the RTD has advantages.

Calibrating Thermocouples 796
WILLIAM F. ROESER—describes NBS methods of calibration.

Total-Temperature Measurement 800
FRANK D. WERNER—total-temperature is the temperature measured by a probe that arrests and converts to heat the kinetic energy of a high-velocity gas.

High-Temperature Gas Thermometry 801
RESULTS of an NBS study of electric-arc techniques as sources of stable controlled gas temperatures to 20,000 K.

Temperature-Probe Response Time 804
ALVIN B. KAUFMAN—response time of a temperature probe is one of the most important parameters in temperature measurement and control.

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INSTRUMENTS AND CONTROL SYSTEMS

VOL. 33 NO. 5
MAY, 1960

PRINT ORDER THIS MONTH: 37,600

C-R Arbitrary-Function Generator **808**

YUJIRO YAMAMOTO—there are many applications for an apparatus which generates an arbitrary function.

Process Control Systems **816**

FRED D. MARTON—cam-controlled air regulator provides constant nip pressure for bundling fabric on roll; melting furnace uses proportional position control for fuel feed; combustion meter records combustion efficiency continuously; timer cycles exhaust to solve smoke problem and reclaim lampblack.

Flame Temperature Determination **821**

NBS is conducting a program of basic research on the physical and chemical process occurring in flames and other high-temperature gases.

THE JOURNAL of THE SOUTHERN CALIFORNIA METER ASSOCIATION

Mass Flow Measurement **824**

C. M. HALSELL and D. S. CLEVELAND—the only type of flowmeter which does not require specific-gravity, pressure, and temperature corrections is a meter which is sensitive only to the mass rate of flow.

THE SIMULATION COUNCIL NEWSLETTER

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INSTRUMENT & APPARATUS NEWS
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The CMC 700 Series is the only major breakthrough in counting, timing and frequency measuring equipment in the past 10 years. Here is the first successful application of transistors to high frequency counting and timing. Transistors perform all the functions in CMC's 700 series that required 63 tubes in old style counting equipment. These are the most reliable counters ever made.

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By answering an obvious need for a completely new, up-to-date approach to counting and timing instrumentation, CMC has produced solid state instruments with greatly simplified circuitry, using logic "and" and "or" gates.

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Each 700 series instrument weighs only 27 pounds, measures 7 inches high, 17 inches wide, and 14 inches deep. Power consumption is a meager 46 watts, 1/10 the amount for vacuum tube models.

DO ALL THESE JOBS

Measure frequency from dc to 10 mc, time interval from 0.1 μsec, ratio 1 cps to 1 mc and unlimited multiple period selection. Frequency converters available for higher frequencies. The counter also generates time interval marker pulses from 1 μsec to 1 second. Data can be presented on standard decades or inline Nixie tubes. The 700 series will operate digital recording equipment, punches, inline readouts, and other data handling gear.

These Features, Too—Decade count-down time base—frequency divider circuits never need adjustment. Accuracy, ±1 count ±oscillator stability. Sensitivity, 0.25 v rms; input impedance, 25 k ohms/volt.

And The Price—Higher than vacuum tube models. But you can save the difference on down time in the first year. Model 727A Universal Counter-Timer, **$2,750**; Model 707A Frequency-Period Meter, **$2,575**; Model 757A Time Interval Meter, **$1,975.** Rack mount optional at no extra cost. All prices f.o.b. Sylmar, California.

More Information Available—Your nearby CMC engineering representative will be happy to arrange a demonstration and provide you with complete technical information. Or you may write Department 555.

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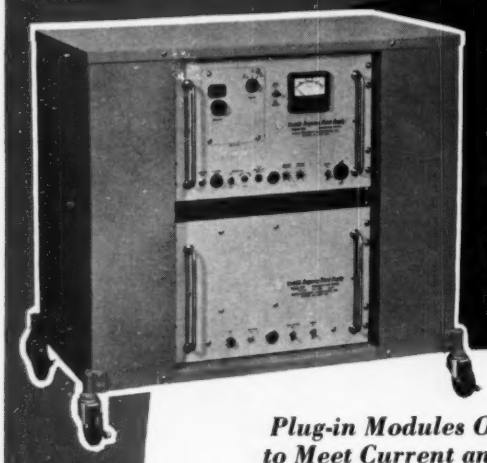
CIRCLE 4 ON READER-SERVICE CARD

Laboratory Power Supplies

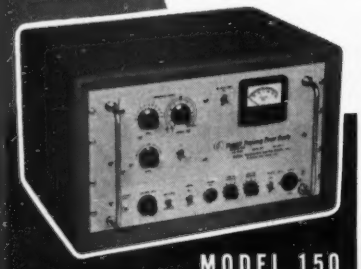


feature CHOICE OF REGULATING OSCILLATORS

Plug-in Modules Offer Flexibility to Meet Current and Future Needs

The Model 500 is a single phase, variable frequency 500 VA supply employing any of four available, plug-in oscillators (or any external oscillator) to produce selected combinations of variable power, frequency, and voltage outputs, having high stability, low harmonic distortion and excellent voltage regulation. Output frequencies are from 40 to 3000 cps, voltage from 0 to 130, harmonic distortion better than 0.5% at 200 VA to 1% or less at 450 VA, and amplitude regulation 0.5% for 5% line fluctuations. It operates from a 115 or 230-volt, 50/60 cps line and uses about 1200 watts.

Positive and negative feedback controls provide adjustment for optimum performance on leading or lagging power factors. All components are driven below rated values for extended, trouble-free service. Price about $1500.



MODEL 150

The Model 150 is a stable, single phase 150 VA supply using a choice of either an LC regulating oscillator which produces output frequencies from 380-2400 cps at 115 volts or a precision 400 cps ±.01% oscillator. In addition, an external oscillator providing 380-2400 cps frequencies at 0-130 volts may be used.

Harmonic distortion is below 1% at 50 watts and 1½% at 150 watts; amplitude variation is 0.5% for 5% line kick; stability is 0.1% ±2 cycles. Controls on front panel provide adjustment of voltage feedback for improved load matching. Operates from 115-volt, 50/60 cps line at 450 watts. Price $595.

Performance is guaranteed. Prices are net, f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

CIRCLE 5 ON READER-SERVICE CARD

I&CS LETTERS TO THE EDITOR

Editor, I&CS:

The appraisal of direct-reading apparatus made by *Instruments and Control Systems* has been of tremendous help to us.

R. R. Schramm
Product Planning Manager
Thomas A. Edison Industries
W. Orange, N. J.

Editor, I&CS:

I have just finished reading your excellent editorial in the March 1960 issue of *Instruments and Control Systems*. Let me say first of all how I appreciate your fine publication, with its exceptional editorials. The editorial section of any publication gives one an insight into the true nature of the publication.

I have been reading your publication for over 10 years and every new issue is better than the last one. I would also like to express my appreciation of your excellent staff, especially Mr. Milton H. Aronson. Few of the publications I receive are fortunate enough to have a publisher such as you have—one who not only knows the field to which his publication is directed but also believes in the field. Of the 20 odd publications in the technical field I receive every month I rate yours at the very top.

Getting back to your editorial I cannot remember of ever reading an article on any subject which hit so many nails on the head . . . Your statement that there is an ART to instrumentation that comes only with experience is so true. This point is the hard one to sell. It is hard to sell the experienced man over the man with a degree to management. In line with this I could use copies of your editorial if available.

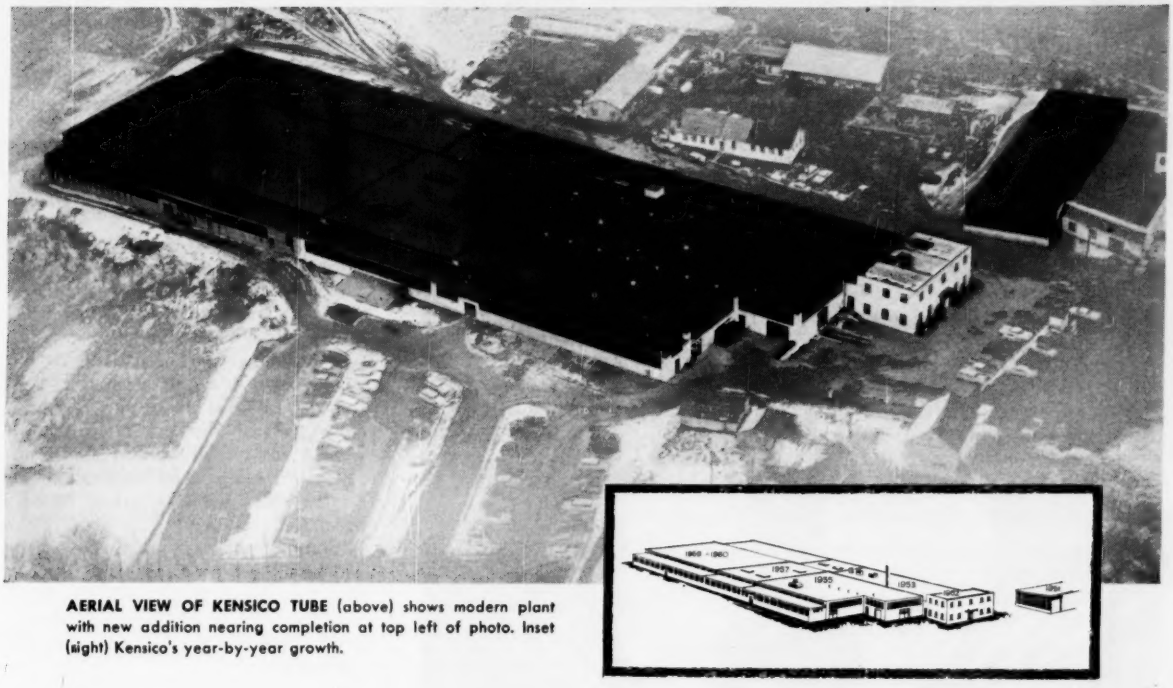
In the field of instrumentation my area of main interest is that of calibration. I have over 10 years in this area of calibration at all levels of laboratories—local, secondary and primary.

Russell G. Smith
Reference Standards Laboratory
Long Beach Naval Shipyard
Long Beach 2, Calif.

Editor, I&CS:

Congratulations on your editorial (The Instrument Engineering Department) in the March issue! Let's hope it opens some people's eyes and

SET FOR THE SOARING SIXTIES



AERIAL VIEW OF KENSICO TUBE (above) shows modern plant with new addition nearing completion at top left of photo. Inset (right) Kensico's year-by-year growth.

PACE-SETTER during a period of phenomenal growth in northern Westchester County, N. Y. Kensico Tube is Mt. Kisco's largest manufacturing business. Products include: hard and soft copper water tube; copper air conditioning, refrigeration and instrumentation tube; and copper tubing for propane gas lines, heat exchangers, automotive and industrial applications. Now, after more than a decade of corporate growth and expansion of production and marketing facilities, Kensico is set to meet the challenge of the SOARING SIXTIES.

IN 1950, CONSTRUCTION of first new building was started. Kensico had been chartered under N. Y. State Law in 1945. Under present management since 1948. Until 1951, company was located in an old cider mill which it leased (floor space 8500 sq. ft.).

TODAY, AFTER PUTTING UP 4 MORE ADDITIONS, Kensico has more than 60,000 square feet of modern fireproof plant and office space.

BY SPRING, 1960, Kensico expects to complete a new 40,000 square foot addition to the plant. Total plant and office space will then exceed 100,000 square feet.

PRODUCTION HAS INCREASED with each addition since 1950. It will be still further increased in both capacity and range of sizes by the new 1960 addition.

IN THE TEN YEAR PERIOD, 1950-1960, Kensico has had a 7-fold growth in gross sales.

EFFECTIVE FEBRUARY 1st 1960, Kensico Tube Company Incorporated, Mt. Kisco, N. Y., merged with Robinson Technical Products, Inc., Teterboro, N. J. Robinson also has other corporate facilities at Hingham, Mass., and Santa Monica, California. The merger strengthens Kensico's position in engineering and metallurgy and places new technological know-how and experience at the disposal of Kensico's customers. Kensico's new name is KENSICO TUBE COMPANY DIVISION — ROBINSON TECHNICAL PRODUCTS, INC.

Kensico Tube
COMPANY DIVISION
Robinson Technical Products, Inc.

MOUNT KISCO, NEW YORK

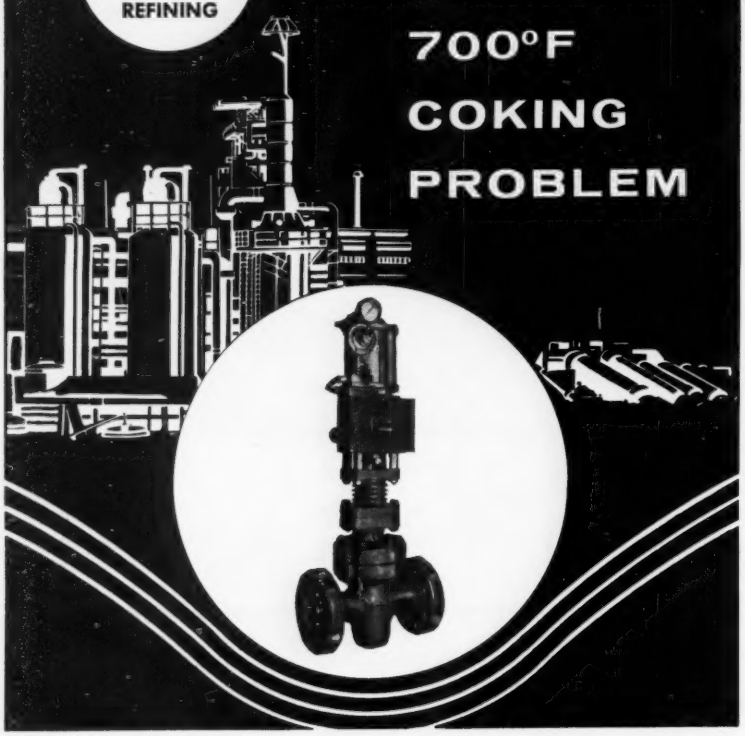
Kensico Products are also Available Through Warehouse Distributors and Sales Representatives in Cambridge, Mass.; Middlebury, Conn.; Buffalo, N. Y.; Lindenhurst, N. Y.; Goshen, N. Y.; Roselle, N. J.; Philadelphia, Pa.; Flourtown, Pa.; Pittsburgh, Pa.; Cleveland, Ohio; Detroit, Mich.; Evanston, Ill.; St. Louis, Mo.; Milwaukee, Wisc.; Durham, N. C.; Berwyn, Ill.; Ft. Lauderdale, Fla.; St. Petersburg, Fla.

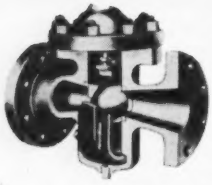
CIRCLE 6 ON READER-SERVICE CARD

CASE HISTORY
TEXAS CITY REFINING

P-K PAUL VENTURI-BALL CONTROL VALVE SOLVES

700°F COKING PROBLEM





- Higher Flow Capacity
- Wide Rangeability
- Positive Shut-Off
- Straight Through, Non-Turbulent Flow
- Low Operating Thrust
- Self-purging
- Highly Resistant to Erosion and Abrasion

"Coking has been a problem on valves for 15 years at this plant. In March, 1958 a P-K Paul Venturi-Ball Valve was installed in the feed line to No. 1 Vacuum Tower. This is heavy oil from Tar Separator Tower and is one of the roughest services in the plant. Oil is flowing at 700°F and contains coke and coke fines. **No previous valve had ever performed satisfactorily prior to this time.**

". . . The valve has given continuous service since being installed. Recommended spare parts are unnecessary — nothing has worn out on these valves."

This is one more example of General Kinetics' ability to solve a particularly tough problem. For operations requiring reliable control valves, General Kinetics offers a complete line of P-K Paul Venturi-Ball Control Valves.

Write today for the 16 page Technical Bulletin GV 101

General Kinetics Corporation

197 South Van Brunt Street • Englewood, New Jersey

CIRCLE 7 ON READER-SERVICE CARD

prompts them to take inventory of their methods of instrument maintenance, installation, selection and design.

Jerold R. Bush
Alliance, Ohio

Editor, I&CS:

We have read Mr. Kaufman's article "Soldering in The Missile Age," which appeared in July, 1958 issue of *Instruments & Automation.* His data and comment on the 95 Cadmium—5 Silver Solder have been added to our material specification on the alloy.

What flux have you found to be most satisfactory with this alloy? Initially we used the Handy-Harmon Tec Solder. Currently Rubyfluid Liquid flux and Rubyfluid Soldering Paste are being used. His comment on the various fluxes would be appreciated.

Commutator leads and exciter parts are being resistance soldered in this plant. Leland Airborne Products manufactures alternators and motor generators for missile and aircraft applications.

A. D. Watson
Leland Airborne Products
American Machine & Foundry Co.
Vandalia, Ohio

The author replies:

The best fluxes to use with 95 Cadmium—5 Silver solder depends on the materials being soldered. I must note that the use of this solder causes rapid erosion of copper solder tips and, therefore, suggest the use of iron or other plating tips. I would suggest that you try one of the following three fluxes: Handy & Harmon No. 155, No. 157, and the use of a silver solder; brazing paste flux has also proven successful with some materials.

In order to secure adequate salt spray and humidity resistance and to eliminate electrical leakage it is important that any flux residue be removed carefully. The method of flux removal depends on the use of flux selected; a cold water rinse immediately after soldering generally flakes some types off, whereas in other cases alcohol or other materials are more effective.

Alvin B. Kaufman, Head
Materials/Devices Section
Research & Analysis Department
Litton Industries
Los Angeles, Calif.

Editor, I&CS:

Are there accepted standard symbols for analog computer elements?

S. T. Novak
Standards Dept.
Bailey Meter Co.
Wickliffe, Ohio

John McLeod replies:

Your question can best be answered by reference to the enclosures: "Preferred Analog Computer Symbols" as used here at Convair-Astronautics; tracings of templates designed and used by Lockheed, Reeves, and Beckman.

You will note that there is some standardization, particularly of the more common components, but there are still many differences.

Certainly there is a need for a standard set of symbols, and it would seem that the Simulation Councils are a natural for the job of selecting them, but they are apparently waiting for the hardware which the symbols represent to become more standardized—and of course this won't happen.

John McLeod, Editor
SIMULATION COUNCIL NEWSLETTER
La Jolla, California

Editor, I&CS:

You quoted me in your March issue, but omitted information that results in an erroneous situation. It was not indicated that the market figures pertain to the industrial electronics market and therefore do not include military electronics market.

Glenn E. Andrews
Arthur D. Little, Inc.
Cambridge 42, Mass.

Corrected item is on page 723.

READER INQUIRIES

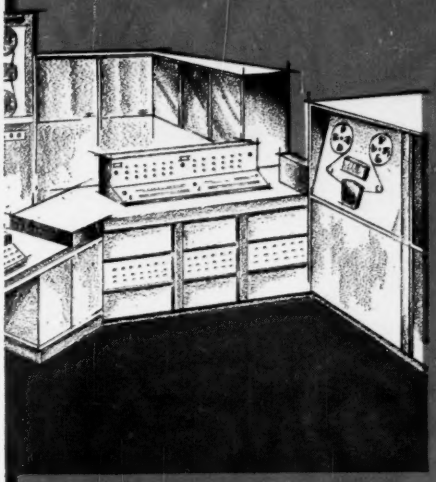
Hi-Press Boiler Water Level Gages

Manufacturer of optical equipment seeks level gages for high-pressure boilers. A-627

Variable-speed Geared Motor

Head of College Mechanical Engineering Dept. seeks a variable-speed geared motor with an output of about one cps to 0.001 cps with accuracy of ±1%. A-628

IF YOU DESIGN SYSTEMS...



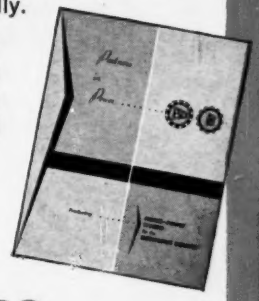
SCIENTIFIC COMPUTERS
BUSINESS AND ACCOUNTING COMPUTERS
DATA PROCESSORS FOR INDUSTRIAL CONTROL
AUTOMATION SYSTEMS FOR PROCESSING PLANTS
AUTOMATIC ASSEMBLY SYSTEMS
MACHINE-TOOL CONTROLLERS AND PROGRAMMERS
TELEMETRY AND TRACKING
MISSILE GUIDANCE GROUND SYSTEMS
MISSILE CHECKOUT AND LAUNCHING SYSTEMS
TACTICAL CONTROL CENTERS
COMMUNICATION NETWORKS

Then you must read the complete and authoritative discussion of "THE APPLICATION OF PRECISE-POWER SETS TO LARGE ELECTRICAL SYSTEMS," contained in our new Bulletin ENG-5900.

Almost every sizeable electronic system **should** use the Precise Power technique to cut costs (typically 50–90%) and increase reliability by at least an order of magnitude . . . don't freeze your power system designs until you have considered it carefully.

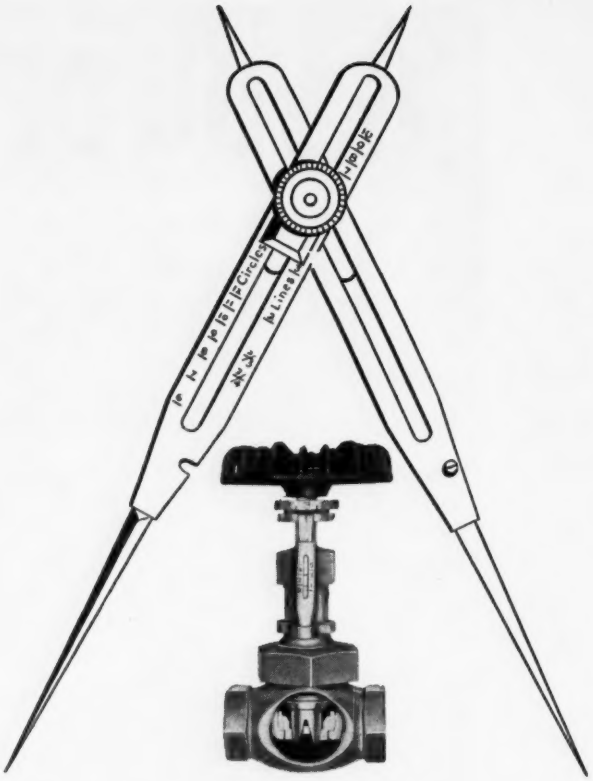
Bulletin ENG-5900 is included in our new 32-page technical manual on PRECISE POWER SYSTEMS for the ELECTRONICS INDUSTRY—**required reading** for systems designers.

May we send you your copy?



ESCO ELECTRIC SPECIALTY CO.
Partners in Power
202 SOUTH STREET, STAMFORD, CONNECTICUT
Fireside 8-6203

RI REGULATORS, INC.



PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required–flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.

Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

HANCOCK "FLOCONTROL" VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Valve Division • Watertown, Massachusetts

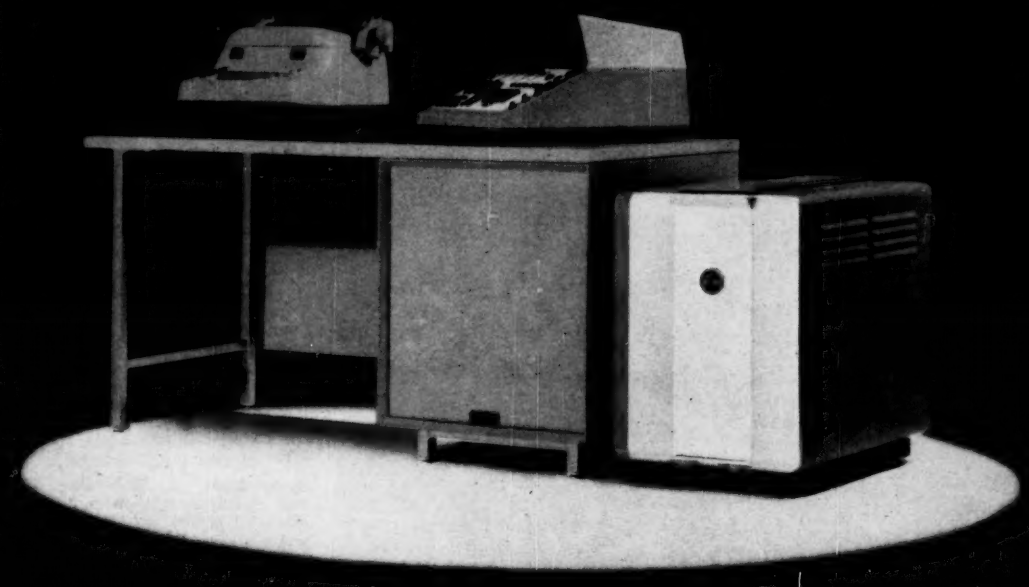
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

HI-88

CIRCLE 9 ON READER-SERVICE CARD

A MASTERPIECE OF FUNCTIONAL DESIGN

RECOMP



COMPACT...VERSATILE...EASY TO OPERATE

The RECOMP computer strikingly demonstrates the four basic principles of design excellence: performance, ease of operation, ease of maintenance, functional styling. It is a masterpiece of practical design.

The magnetic disk memory contains 4096 words, each of 40-bit length, or 12 decimal digits, eight alpha characters, or two program instructions. It retains as many as 8000 instructions or stores more than 49,000 decimal digits of data. Reading speed of the photoelectric tape is 400 characters a second. The exclusive digital readout flashes arabic numerals to reveal contents of any word or register.

RECOMP gives you far more capacity, versatility, and trouble-free service for your money. It's available now—for outright sale or at a moderate monthly rental that includes maintenance. *And there's no extra equipment to buy...no cost of installation.* For information on how RECOMP can solve *your* problems, write Autonetics Industrial Products, Dept. 605, 3584 Wilshire Boulevard, Los Angeles 5, California.

Digital computers by Autonetics

INDUSTRIAL PRODUCTS

A DIVISION OF NORTH AMERICAN AVIATION, INC.

Other Offices: New York, Chicago, Washington, D.C.

NEW...

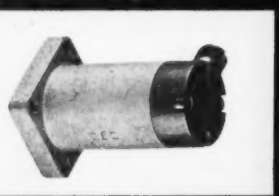
FOR VIBRATION MEASUREMENT

A hint of vibration is detected instantly by CEC's new omnidirectional 4-123A vibration transducer. This rugged pickup assures a frequency response of 45 to 2000 cps... provides constant damping over an operating temperature range of −65° F. to +500° F.

Hermetically sealed against sand and dust, the 4-123A functions perfectly in oily, corrosive and humid atmospheres. It weighs only 4.25 oz., including connector, and is 2⅛" high.

Wherever unbalance is present —in engines, machinery, motors or generators—CEC's line of vibration transducers ensures fast detection, quickly helps solve your vibration problems.

For complete information, call your nearest CEC sales and service office or write today for Bulletin CEC 1596-X17.



Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

IGS EVENTS

June 1-3

Sixth Annual Instrumental Methods of Analysis Symposium, Queen Elizabeth Hotel, Montreal, Canada. For information write N. B. Ward, Laurentian Valve & Fittings, Ltd., 4060 MacKenzie St., Montreal 26, Quebec, Canada.

June 1-3

Sixth Annual Radar Symposium, University of Michigan, Willow Run Laboratories, Ann Arbor, Mich. For information write Coordinator, 6th Radar Symposium, Willow Run Labs., P.O. Box 2008, Ann Arbor, Mich.

June 1-2

Symposium on Recent Advances in Solid State Devices, on campus of Marquette University. For information write Stanley Krupnik, Jr., Assistant Chairman of Electrical Engineering, Marquette University, Milwaukee 3, Wis.

June 5-10

Seminar on Electrical Contacts, on campus of Pennsylvania State University. For information write Ralph E. Armington, Associate Professor of Electrical Engineering, Pennsylvania State University, University Park, Penna.

June 12-17

Seminar on Design Engineering, on campus of Pennsylvania State University. For information write Maurice S. Gjesdahl, Professor of Mechanical Engineering, Pennsylvania State University, University Park, Penna.

June 13-17

Symposium on Molecular Structure and Spectroscopy, on campus of Ohio State University. For information write R. A. Oetjen, Dept. of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

June 14-17

Seminars on Engineering Administration, Systems Simulation with Digital Computers, Statistical Decision-Making, etc., on campus of Cornell University. For information write J. W. Gavett, Upson Hall, Cornell U., Ithaca, N. Y.

June 14-August 22

Special Summer Program on Fluid Power Control, Heat Transfer, Inertial Guidance, Strain Gages, Modulation Theory, Spectroscopy, etc., on campus of Massachusetts Institute of Technology. For information write John I. Mattill, Associate Director, M.I.T. Summer Program, Cambridge 39, Mass.

June 16-18

Fifth Annual Symposium and Exhibit of American Scientific Glassblowers Society, Penn-Sheraton Hotel, Pittsburgh, Penna. For information write W. E. Barr, Gulf Research & Development Company, P.O. Box 2038, Pittsburgh 30, Penna.

← CIRCLE 10 ON READER-SERVICE CARD

June 20-21

Chicago Spring Conference on Broadcast and Television Receivers, Graemere Hotel, Chicago, Ill. For information write I.R.E., 1 East 79 St., New York 21, N. Y.

June 22-24

1960 Conference on Electronic Standards and Measurements, National Bureau of Standards Laboratories, Boulder, Colorado. For information write Herbert Finke, Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

July 28-29

Denver Research Institute's 7th Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colorado. For information write W. H. Eichelberger, University of Denver, Denver 10, Colorado.

August 1-3

4th Global Communications Symposium, Statler Hilton Hotel, Washington, D.C. For information write Ralph L. Clark, Office of Director of Defense Research and Engineering, Washington 25, D.C.

August 1-5

Gordon Research Conferences on Instrumentation, Colby Junior College, New London, New Hampshire. For information write Dr. W. George Parks, Gordon Research Conferences, Dept. of Chemistry, University of Rhode Island, Kingston, Rhode Island.

August 1-12

Summer Program on Modulation Theory and Systems, on campus of Massachusetts Institute of Technology. For information write Elie J. Baghdady, Dept. of Electrical Engineering, MIT, Cambridge, Mass.

August 3-6

Infrared Spectroscopy Institute Gas Chromatography Session, on campus of Fisk University. For information write Infrared Institute, Fisk University, Nashville, Tenn.

August 24-25

1960 Cryogenic Engineering Conference, on campus of University of Colorado. For information write K. D. Timmerhaus, Dept. of Chemical Engineering, Boulder, Colorado.

August 29-31

Appalachian Gas Measurement Short Course, on campus of University of West Virginia. For information write R. E. Hanna, School of Mines, University of West Virginia, Morgantown, West Va.

September 7-9

1960 Joint Automatic Computer Conference, on campus of Massachusetts Institute of Technology. For information write JACC Chairman William D. Archibald, Energy Control Co., 5 Beekman St., New York 38, N. Y.

CIRCLE 11 ON READER-SERVICE CARD ⟶

Big Performance in a Small Package with CEC's Low-Cost 5-740

The *all-new* 5-740 is at home in the lab or in the field, aboard a submarine, or with larger systems from missile checkout and back-up to industrial control. In or out of its carrying case it mounts in a standard 19″ rack... accepts 10 ½″ reels with all standard hubs and tape widths... provides simplified, fool-proof pushbutton control of any function in any sequence in either direction. The 5-740 uses all solid-state electronics... gives gentle, controlled tape handling... packs complete 14-channel record and reproduce capability in a 30-inch vertical rack space.

There is much more to the 5-740 that can change your thinking about tape recorders, and the modest price tag is a feature, too. Call your nearest CEC sales and service office for detailed information, or write today for Bulletin CEC 1636-X1.

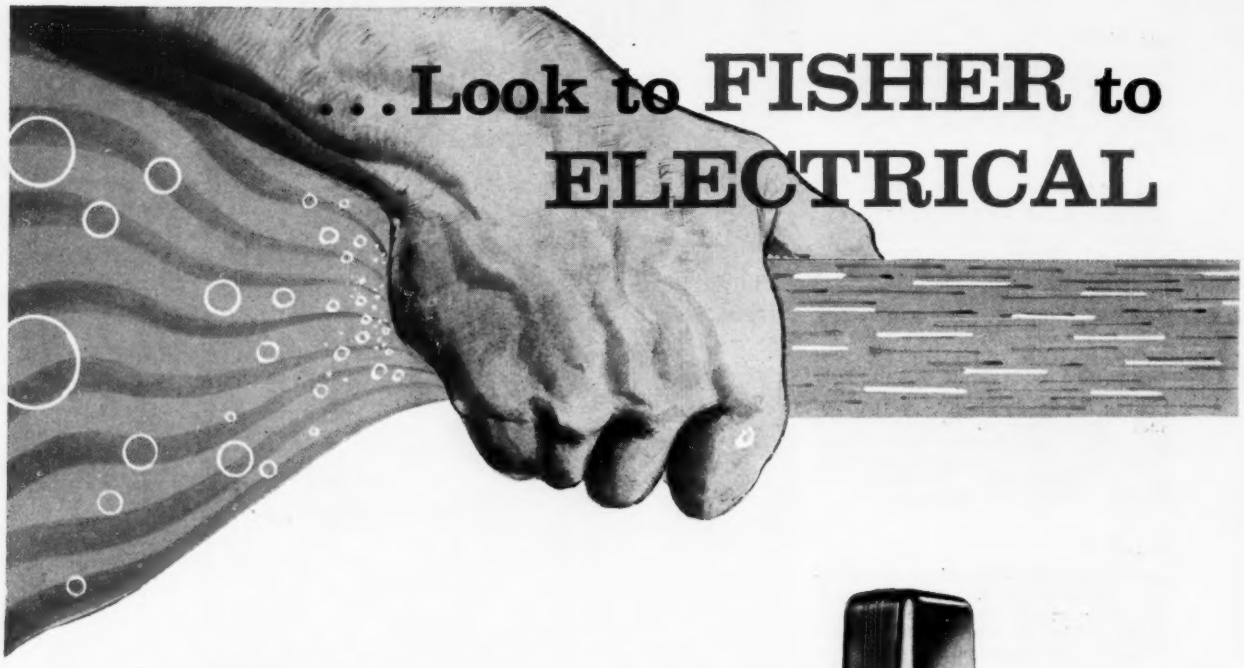
Portability demands little compromise in performance. Flutter, tracking, overall performance and reliability approach or equal the most elaborate and expensive instrumentation recorders.

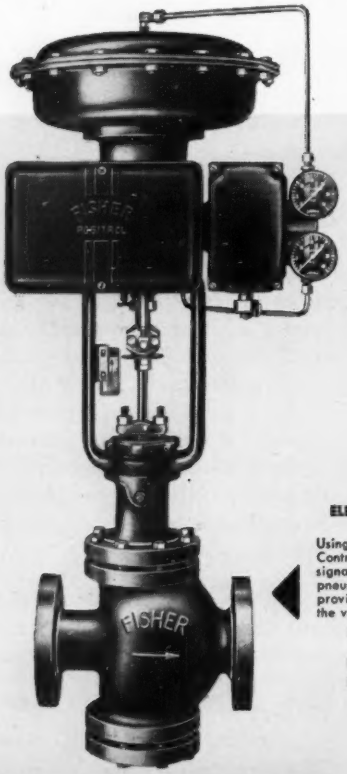
DataTape Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell • FINER PRODUCTS THROUGH MAG[illegible]

...Look to FISHER to ELECTRICAL





THE ELECTRO-PNEUMATIC POSITIONER "E-POSITROL"

Using a conventional Fisher diaphragm Control Valve, the E-Positrol receives a Ma signal and translates this to a proportional pneumatic signal to a positioner which provides the speed and power to operate the valve.

Input Current: 1-5 ma; 4 to 20 ma, 10 to 50 ma D.C.

Linearity—1% of full scale.

Resolution Sensitivity—0.1% of input range.

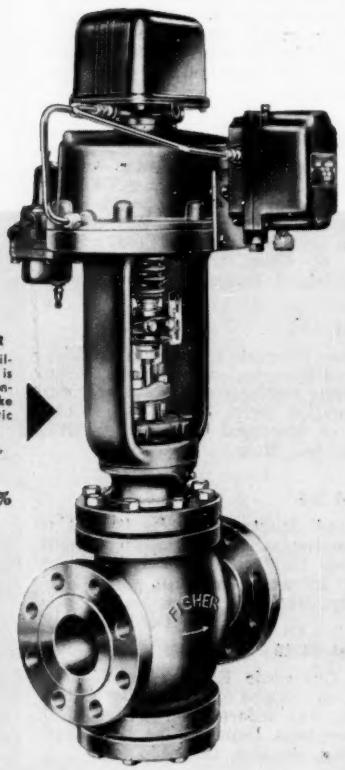
THE PNEUMATIC OPERATED PISTON "P.O.P." WITH ELECTRO-PNEUMATIC TRANSDUCER

The compactness, speed and power available from the FISHER Series 470 P.O.P. is readily made available in electrical control systems with the use of the yoke mounted Type 545 Electro-Pneumatic Transducer.

Input Current: 1 to 5 ma, 4 to 20 ma, 10 to 50 ma, d.c.

Linearity—1% of Full Range

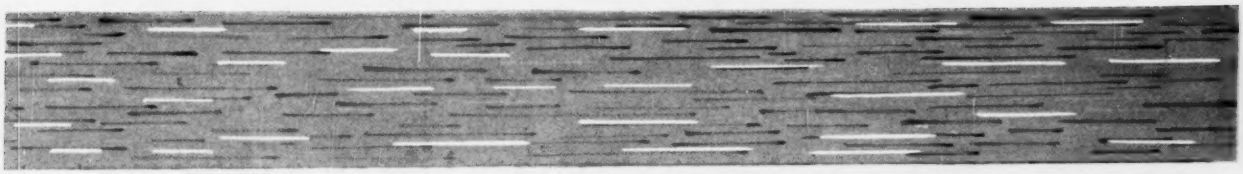
Resolution Sensitivity—Less than 0.1% of Input Range.



IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

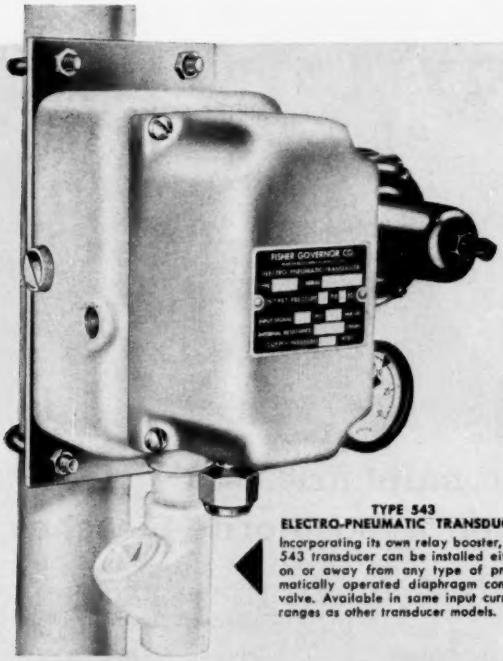
CIRCLE 12 ON READER-SERVICE CARD

supply the muscles for your CONTROL SYSTEMS

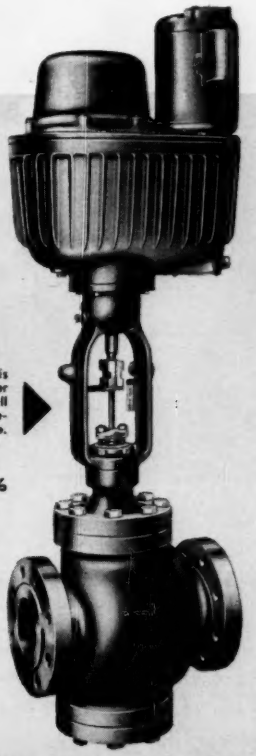


The old adage, "a chain is as strong as its weakest link" can be equally applied to the "muscle" or more correctly the final control element on any control loop. The importance of a control valve in an electronic system should never be considered lightly and that is why you should look to Fisher for assurance in furnishing dependable and accurate control valves for your electrical or electronic system.

Described below are three types of actuators that offer an exceptionally practical and economical approach for control valves in electrical control loops.



TYPE 543
ELECTRO-PNEUMATIC TRANSDUCER
Incorporating its own relay booster, the 543 transducer can be installed either on or away from any type of pneumatically operated diaphragm control valve. Available in same input current ranges as other transducer models.



THE TYPE 350
ELECTRO-HYDRAULIC ACTUATOR
In electrical control systems where air is not available or desirable, the Fisher Electro-Hydraulic Actuator provides all the necessary requirements for a dependable and accurate control valve.

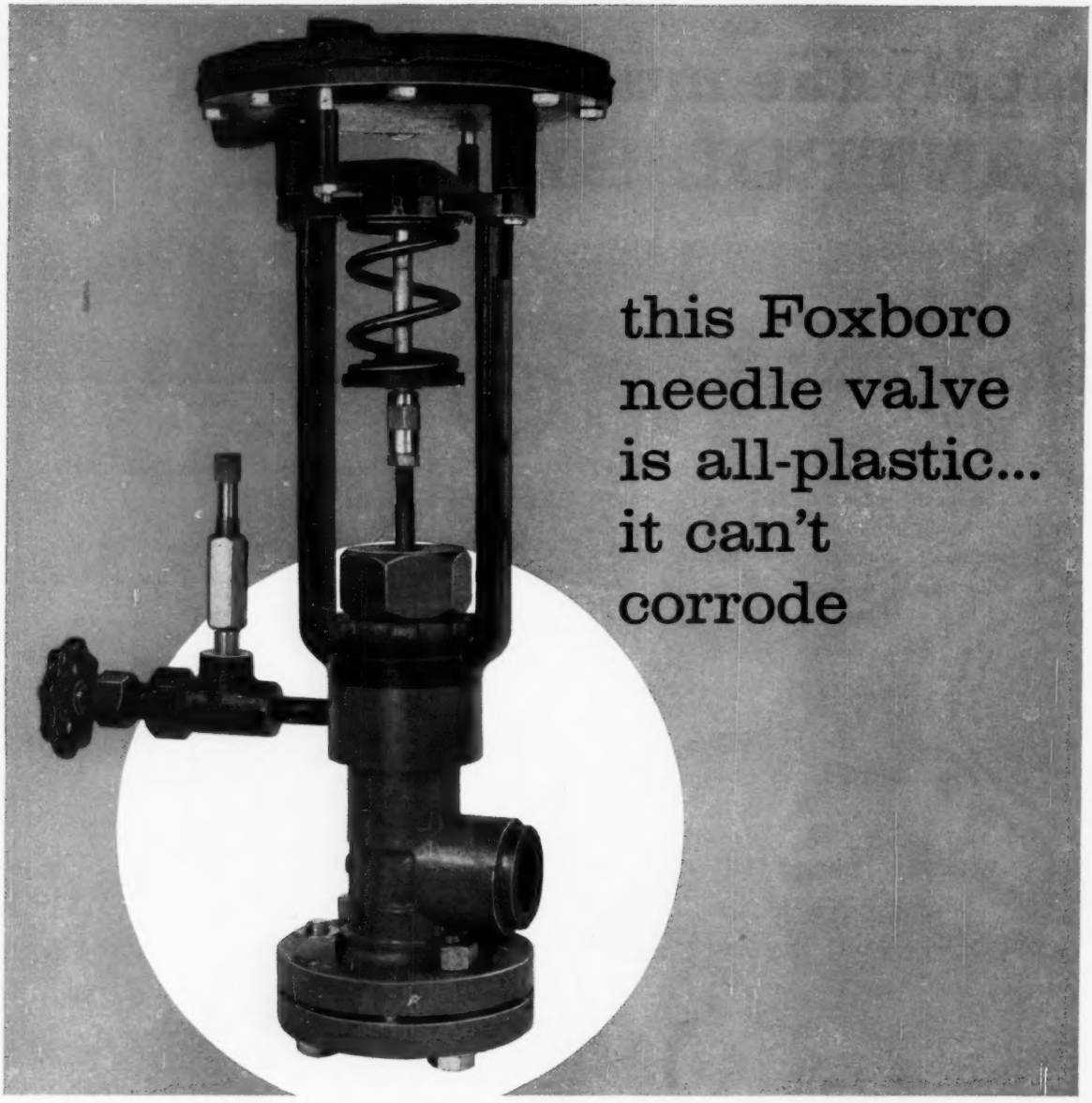
Maximum Stem Thrust..2000 pounds
Stroking Speed.....0.37 in./sec.
Resolution Sensitivity...less than 0.05%

FISHER®

SINCE 1880

FISHER GOVERNOR COMPANY
Marshalltown, Iowa / Woodstock, Ontario / London, England
BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PA.

CIRCLE 12 ON READER-SERVICE CARD



this Foxboro needle valve is all-plastic... it can't corrode

safe... even for nitric, sulphuric, and hydrochloric acids... alums and hypochlorite bleaches

A valve completely fabricated of chemically inert PVC — right down to the valve stem. It's the new Foxboro all-plastic needle valve.

Nothing but chemically inert plastic comes in contact with the process fluid. Downtime for replacing corroded valves is eliminated. Smooth, impervious plastic surfaces minimize product build-up.

Foxboro all-plastic parabolic needle and matching seat are produced with toolmaker's precision from normal-impact grade PVC. Even at lowest flow rates, valve will deliver precise control of fluid flows.

Properly applied, and correctly installed, the Foxboro PVC valve will normally last longer than even the most expensive valve of corrosion-resistant alloys. Ask your Foxboro Field Engineer about it, or write for Bulletin 5C-16. The Foxboro Company, 465 Norfolk St., Foxboro, Mass.

Condensed Specifications

Sizes up to 1 inch
Maximum Pressure Rating
75 psi at 75F
50 psi at 140F
Temperature Rating
140F maximum
30F minimum

FOXBORO
REG. U.S. PAT. OFF.

CIRCLE 29 ON READER-SERVICE CARD

Department of Commerce and SEC reports that American industry will spend $37 billion in 1960 for new plants and equipment, up 14% over 1959. Processing industries will spend about $6 billion of this, as follows: (data in millions):

	1957	1958	1959	1960
Petroleum and coal products	$3453	$2431	$2491	$2930
Chemicals and allied products	$1724	1320	1235	1642
Paper and allied products	811	578	630	696
Primary nonferrous metals	814	441	313	372
Rubber products	200	134	190	254
				5,904

Source: Department of Commerce, Securities and Exchange Commission.

Dept. of Commerce (BDSA) estimates microwave components market at $300 million for 1958, as follows: Microwave tubes—$108 million; Microwave antennas—$95 million; Microwave components—$97 million.

Hearing aid market was $31.7 million in 1956, $31.9 million in 1955, $29.0 million in 1954, says Census Bureau. 1960 sales are forecast at $40 million by L. A. Watson of Maico Electronics, plus $10-$12 million for batteries and accessories.

Precision measuring instruments manufacturing industry, whose exports are running better than $270 million annually, can raise this level if trade restrictions imposed by foreign governments are eased, says industry spokesmen at a Department of Commerce conference.

At end of 1958, US electric power generation was 160 million kw (Russia had 53 million kw) says C. E. Eble of Consolidated Edison. U. S. will have 250 million kw by 1960 (Russia 113 million kw). Both produce 80% by thermal means, 20% by hydro. Plants in US require 0.2 to 0.5 operating personnel per 1000-kw capacity; Russia uses 2 to 2.5 persons. Russia has an 800,000-volt transmission system under construction; highest-voltage line in US is now 345,000 volts. At end of 1957 we had 240,000 miles of transmission lines; Russia had 62,000. Average home use in US is 3400 kwhr per yr; Russia only 400 kwhr per year.

Crystal filter sales are estimated roughly at $1.5 million for 1960, up 25% over 1959, by Electronics magazine.

Market for educational TV will be 2.75 million sets in 1965 says GE market analysts.

Industrial test, recording and measuring instrument market (not including Military) is estimated by G. E. Andrews of A. D. Little as follows: (millions of dollars):

	1959	1960		1959	1960
Oscilloscopes	$10	$11	Transmitter test equipment	3	3
Oscillographs	15	16			
Volt-ohmmeters	9	9	R-f measuring equipment	7	8
R, C, L measuring equipment	3	4	Indicating Instruments	25	27
Analyzers for engine testing	25	25	Recording Instruments	30	30
Tube testers	6	5	Ultrasonic	4	5
Microwave test equipment	10	15	Other test equipment	88	102
Signal generators	15	15	Total	$250	$275

gold plating for electrical and electronic components

Recently, the use of gold electroplates have been extended to many new functional applications especially in the field of electronics where the tarnish resistance and low electrical resistivity of gold are most useful. A complete line of precious metal plating solutions for both decorative and functional purposes are available from stock.

ATOMEX is a 24K gold immersion solution that permits the deposition of a thin, dense, uniform layer of 24K gold on printed circuits and metallized plastics by means of a simple bath. Atomex deposits gold by Ionic displacement—it is the first practical gold immersion solution containing no free cyanide. The Atomex deposit is more permanent and less expensive than electroplating of comparable thickness. Costly analytical control is unnecessary.

Engelhard experience is at your service. Call for technical assistance or write for literature.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N. J.

Atomic Number	79
Atomic Wgt.	197.20
Crystal Structure	Face center cubic 4.07A°
Density	20°C = 19.3 G/CM³
Melting Point	1063°C
Specific Resistance	13.2 OHMS/MILL/FOOT
Thermal Conductivity	0.71 c g s UNITS (20°C)
Coef. Linear Expansion	14.2 Micro Inches /°C (20°C)
Hardness	Rockwell 15 T Scale = 24
Tensile Strength	P.S.1 x 1000 = 18
Magnetic Susceptibility	.15 x 10^{-6} C.G.S. Units (18°C)

fine wire, thin foils, ribbon and tubing in noble metals and their alloys, for all applications.

The unique combination of properties of the noble metals continually recommend them for industrial applications. Our modern melting, wire drawing, rolling and heat treating equipment coupled with long experience in the field is at your service for production of standard and special items.
WIRES: Bare drawn wire of ductile materials down to .004" —High temperature thermocouple wires—High temperature furnace windings — Potentiometer and Resistance wires — Platinum clad tungsten wire.
FOILS: In platinum, palladium and gold down to .0001"— In iridium and rhodium as thin as .001".
TUBING: Seamless in platinum, palladium, gold and their alloys. Sizes from .018" with .004" wall up to 1½" with .042" wall.

For complete information write for our leaflets, "Fine Wire, Foils, Ribbons" and "Noble Metal Thermocouple Wire".

BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N. J.

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PROMPT PRECIOUS METAL SCRAP RECOVERY SERVICE • ENGELHARD PROCEDURES RECOVER

FOR PLATING, CIRCLE 13 ON READER-SERVICE CARD

FOR PLATINUM, CIRCLE 14 ON READER-SERVICE CARD

BAKER CONTACT DIVISION

precious metal contacts for high-reliability

For high-reliability and long operating life, precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold are very definitely indicated. These contacts provide unmatched high resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications. Write for Baker Contact catalog.

BAKER CONTACT DIVISION • 207 GRANT AVE., E. NEWARK HARRISON P. O., N. J.

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EXECUTIVE OFFICES:
113 ASTOR STREET • NEWARK 2, NEW JERSEY

CHEMICAL DIVISION

for low cost purification and drying of hydrogen and other gases

The Deoxo Catalytic Purifier is combined with an extremely efficient automatically operated drying unit to provide oxygen-free hydrogen that is ideally pure and dry. The combined units are identified as the Deoxo Dual Puridryer. It supplies hydrogen with less than one part oxygen per million — dried to a dew point of —100°F. *No inert gas purging is needed.* The Deoxo Dual Puridryer can also be used with other gases such as: Nitrogen, Argon, Helium and saturated hydrocarbons, with equally fine performance. Write for descriptive literature.

CHEMICAL DIVISION • 113 ASTOR STREET NEWARK, N. J.

S. A., BOGOTA • ENGELHARD INDUSTRIES S.A.R.L., PARIS • GLOVER & GOODE PTY., LTD., MELBOURNE • ENGELHARD INDUSTRIES, K. K., TOKYO • ENGELHARD INDUSTRIES, PTY., LTD., MELBOURNE • ENGELHARD INDUSTRIES, LTD., ZURICH • INDUSTRIE ENGELHARD S. P. A., ROME • GUILIANO STACCIOLI—METALLI PREZIOSO S.P.A., ROME • INVERSIONES EN INDUSTRIES NACIONALES, S.A., BOGOTA. **ASSOCIATED COMPANIES:** KALIE-CHEMIE-ENGELHARD KATALYSATOREN G.M.B.H., HANOVER

100% OF ASSAYED PRECIOUS METAL CONTENT • IRVINGTON-BAKER REFINING DIVISION

FOR CONTACTS, CIRCLE 15 ON READER-SERVICE CARD

FOR PURIFIER, CIRCLE 16 ON READER-SERVICE CARD

YEAR 'ROUND BONUS!

You Get More Than Just a Valve When You Buy BS&B's *Super* 70

Specification of BS&B Super 70 Diaphragm Control Valves on your next job will assure you of getting all of the following:

1. High Quality Product . . . The BS&B Super 70 Diaphragm Control Valve has high efficiency and stability. In addition to thousands of hydraulic flow tests performed in the laboratory, analysis of operating data gathered from Super 70's on stream in customer plants substantiate their excellent performance.

2. Application Engineering . . . Today's complex processing problems require detailed analysis to determine proper instrumentation and control applications . . . accurate control valve sizing. This is a regular service to Super 70 customers.

3. Start-up Assistance . . . After helping customers select the right valve for a specific job, BS&B follows thru by assisting at plant start-up time.

4. Time-saving Scheduled Maintenance . . . With the patented clamp ring—float ring closure, valve maintenance can be done in a fraction of the time required by conventional type valves . . . an economic must in future valve specifications.

Clamp Ring —
Float Ring Closure

Flanged —
Gasket Closure

BS&B Super 70 Valves are available in either clamp ring—float ring, sealed bonnet or flanged-gasketed body closures. Whichever type you choose, when they're "on stream" you'll *know* that they're exactly right for the job.

Call your nearest BS&B office or representative *now* to discuss your present and future valve requirements. Or if you prefer, write for detailed information.

OVER 60 YEARS BS&B ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-V5

7500 East 12th Street

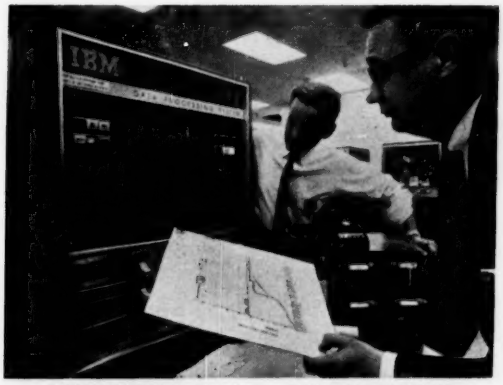
Kansas City 26, Missouri.

CIRCLE 17 ON READER-SERVICE CARD

Computers Linked by Microwave

CANOGA PARK, CALIF.—Rocketdyne, a division of North American Aviation, is using the world's most powerful network of commercial computers to "talk" to each other over microwaves and telephone wires.

Great savings have been accomplished in experimentation and testing and by giving management the daily status of every program, which has included the Thor and Atlas engines and the newer Saturn and F-1 power plants.



At a recent demonstration it was shown how Rocketdyne's engineering labs and test stands in California, Texas and Missouri are linked by leased wires to two large-scale IBM computers at the division's headquarters here. The Rocketdyne system in turn is connected by microwaves to four more IBM computers at North American's Los Angeles division, thirty miles away. The six computers can "talk" to each other at a rate of 75,000 words per minute. In twelve minutes, for instance, a computer produces 200 graph reports, which show management the budget status of every project. Production status of thousands of components for the rocket engines is available in minutes from the memories of the IBM RAMAC 305 computer.

Rocketdyne's data transmission system handles an average of 44 million words a day. This information is microwaved from one location to the other at a rate 500 times faster than that of human speech.

ICS NEWS

Rehabilitation by Computer

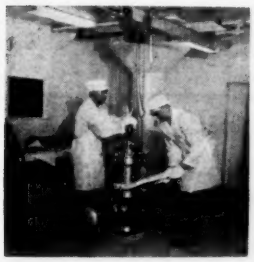
WASHINGTON, D. C.—Twenty young men, now serving sentences in a Pennsylvania State correctional institution (CampHill, Pa.) have embarked on a unique program of rehabilitation, through which they hope to return to life "outside the walls" as electronic computer experts.

The State's Department of Property and Supplies has joined with Pennsylvania Department of Justice officials in setting up the pilot training project, and will make its Univac computer in Harrisburg available to the class. Remington Rand, makers of the Univac, conceived and designed the project, and is providing instructors and training equipment.

There has been so much interest in the course that two men have asked to have their opportunity for parole delayed in order to participate. Emphasis in the course will be on computer "programming"—preparing data for processing by the computer. First, however, a complete orientation in data processing will be given.

BAILEY METER has concluded an agreement with **PACKARD BELL COMPUTER CORP.** to use this company's "second-generation" solid-state digital computer in Metrotype digital systems to provide compact closed-loop computer control and information systems.

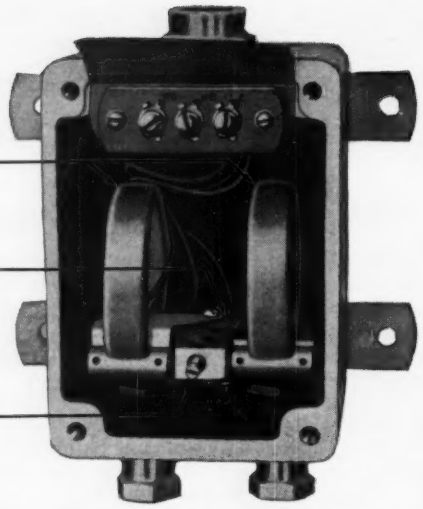
GENERAL ELECTRIC's new mass flowmeter has made possible direct measurement in lb of ethylene flow with an accuracy of 1%. Ethylene's non-compliance with physical laws of gas behavior has previously necessitated time-consuming calculations when using orifice meters.



Fisher Governor White Room.

FISHER GOVERNOR now has in operation its "white room" for processing and assembly of control equipment for nuclear and cryogenic applications where equipment must be absolutely clean and free of any oils.

AIRBORNE INSTRUMENTS LAB (AIL) has formed a scientific partnership with the Central Radio Propagation Lab of the National Bureau of Standards to develop payload and ground control equipment for the Satellite-Borne Topside Ionospheric Sound System. The program will attempt to determine the electron density of the ionosphere "from above."



INSTRUMENT QUALITY DIFFERENTIAL SWITCH

Senses pressure differences from 4 p.s.i. to 9000 p.s.i.

Proof Pressures ranging from 500 to 12,000 p.s.i.

A good illustration of this switch function is its application on multiple stage compressors. If a failure occurs in one of the stages the switch will signal the pressure difference change or shut down the system to prevent damage.

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS which require that the pressure switch be mounted absolutely vertical, which make it critical to vibration.

ASK FOR NEW CATALOG 9-PS FREE

PRESSURE SWITCH DIVISION

Barksdale valves

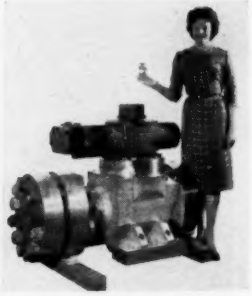
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

CIRCLE 18 ON READER-SERVICE CARD

ICS NEWS

DAYSTROM's Control Systems Div. is delivering two more computer systems, similar to the installation in successful use at Sterlington Station of Louisiana Power and Light Co., to southern electrical power utilities: Carolina Power and Light Co.'s 182-kw generating station at Darlington, N. C., and Gulf States Utilities Co.'s 150-kw station at St. Gabriel, La. are the recipients.

Daystrom Computer



Hydromatics Largest ►

HYDROMATICS, INC. has built eight of the world's largest ball valves for static testing of Rocketdyne's "Nova" engine which will power a rocket nearly thirty-times more powerful than the Atlas. The giant valves must open and close in less than 1/3 sec.

FIRST SYSTEMS SYMPOSIUM was recently held at Case Institute with *Dr. Donald Eckman* as chairman and *Dr. Simon Ramo* as keynote speaker. The three-day sessions brought together leaders in science and engineering who were invited to presentations and discussions on the philosophy and morphology of systems engineering.

M-H's BROWN INSTRUMENT DIV. has developed and built a self-starter control system for the AEC's plutonium recycle test reactor (PRTR) now being built at Hanford, Wash. which uses a moderator level instead of control rods to regulate the rate of fission. The control system will electronically sense the reactor period and automatically control this variable, thus taking the human error out of the start-up period.

ICS PEOPLE IN THE NEWS

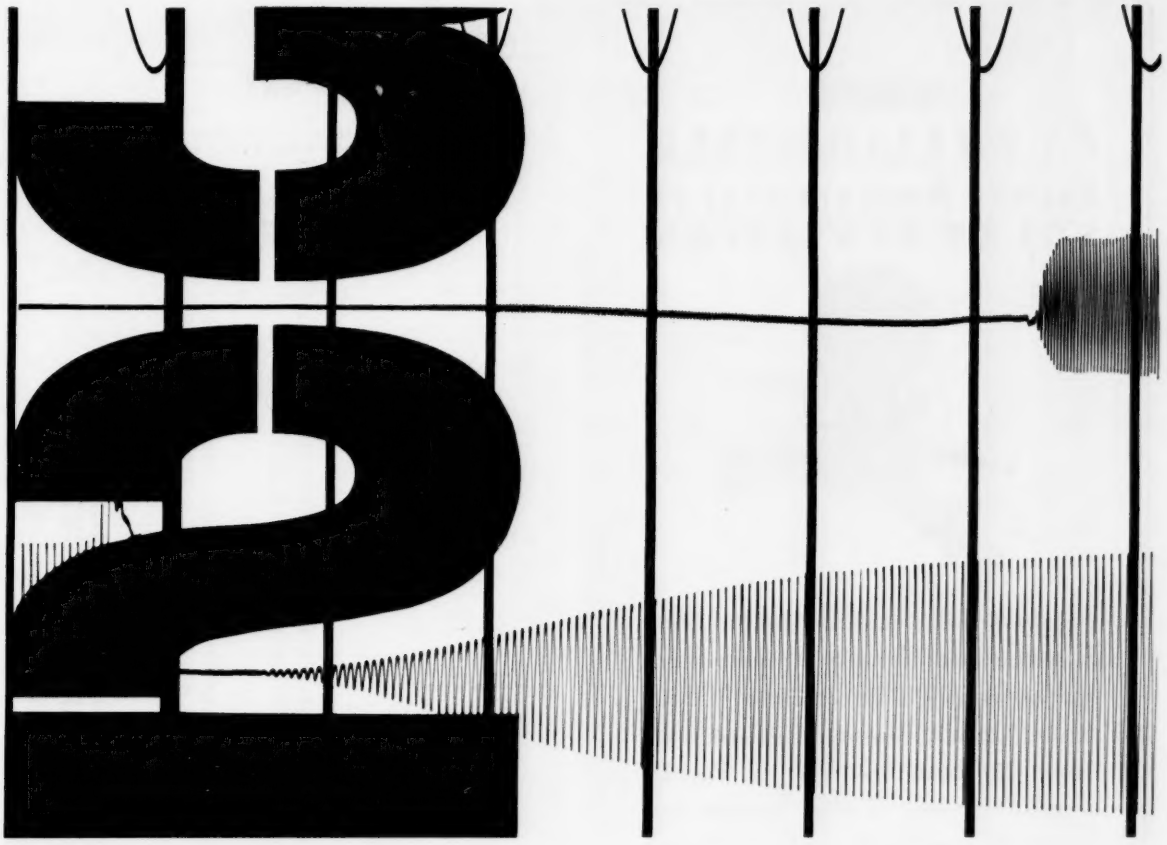
BARTON INSTRUMENT CORP. announces that *Claude B. Nolte* will head the program of advance product planning and research.

C. B. Nolte
Barton

A. F. Platt
Hydromatics

HYDROMATICS has promoted *Austin F. Platt* to national sales manager.

HUGHES AIRCRAFT has appointed *Phil N. Scheid* personnel manager of the ground system group.



Complete line . . . prompt delivery. That sums up Du Pont Lino-Writ Photorecording Paper. Lino-Writ 4 is the fastest, toughest, whitest paper available. Writing speeds up to 50,000 inches per second. Ultra-thin, all-rag stock has unusual wet or dry strength.

We also offer Lino-Writ 1, 2 and 3 . . . one for every test requirement. And, they're all backed up by Du Pont's prompt, efficient delivery designed to save you time.

For more information on our photorecording papers, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

This advertisement was prepared exclusively by Phototypography.

LINO-WRIT

DU PONT
REG. U.S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

CIRCLE 19 ON READER-SERVICE CARD

EPLAB

PYRHELIOMETER
For the Measurement of SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

2 Sheffield Ave.

Newport, Rhode Island U. S. A.

CIRCLE 20 ON READER-SERVICE CARD

ICS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1960 THRU APRIL 18, 1960

	High	Low	Price As Of 4/18/60
ACF Industries	52	45 3/4	48
Aeroquip Corp.	40 5/8	33	37 3/4
Allis Chalmers	40	31 7/8	32 7/8
Amer. Chain & Cable	51 3/4	44 1/4	47 7/8
Amer. Mach. & Foundry	63 3/8	49 1/2	63 1/8
Amer. Macn. & Metals	58 1/4	44 1/2	49
American Optical	48	43 1/4	44
Amer. Tel. & Tel.	95 3/4	79 7/8	95 5/8
Ampex Corp.	42 1/4	32 5/8	33 3/8
Bausch & Lomb Optical	46 3/4	34 1/2	45 1/2
Beckman Instruments	78 1/4	62 1/2	73
Bell & Howell	50	37 5/8	43 3/4
Bendix Aviation	74 1/2	62 1/2	69
Boeing Airplane	32 3/4	23	23 5/8
Bullard	17 7/8	13 1/8	13 1/2
Bulova Watch	18 7/8	15 1/4	15 1/8
Burroughs	35 3/8	28 3/4	33 3/8
Carborundum	49 7/8	43	45 1/4
Cinn. Milling Machine	38 1/2	30 1/4	32 1/4
Clevite	57	42	54 3/4
Columbia Broadcasting Sys.	45	36 5/8	39 3/4
Consol. Electronics	52	42 1/4	48 7/8
Cornell Dubilier	30 1/2	17 3/4	22 1/2 Bid 23 1/2 Asked
Corning Glass	147 1/2	124	145 1/2
Curtiss Wright	31 1/8	20	21
Cutler-Hammer	96	82	91
Daystrom	43 1/4	35 3/4	44 3/8
Douglas Aircraft	42 3/8	30 3/4	31 1/4
Eastman Kodak	114 3/4	94	114 1/4
Eaton Mfg.	40 7/8	37 1/8	39 7/8
Electric Auto-Lite	54 1/2	47 1/2	48
Elgin Watch	13 3/4	11 1/2	12 7/8
Emerson Electric (new)	42 1/8	33	42 3/4
Food Mach. & Chem.	56 3/8	46 1/4	50 3/4
Garrett	54 7/8	44	46 5/8
General Controls	29 5/8	22 1/2	22 1/2
General Dynamics	53 3/8	41 5/8	42 5/8
General Electric	99 7/8	84 5/8	92 7/8
General Instrument	31	22 1/2	27 1/4
General Mills	31	26 3/4	27
Gen. Precision Equip.	54 3/8	44 1/4	52 3/8
Gen. Railway Signal	34 7/8	27 1/2	33
Gen. Tel. & Elect.	86 1/2	70 5/8	86 1/4
General Time	127	92	105 7/8
General Tire & Rubber	81 3/8	62 1/4	62 1/2
International Bus. Mach.	471 1/4	407 1/4	465
Internat'l. Tel. & Tel.	40 1/2	32	41 1/2
I-T-E Circuit Breaker	44 1/4	29 1/2	29 1/2
Lear Inc.	20 1/4	15 1/8	15 5/8
Litton Industries	81 1/2	57 5/8	76 5/8
Lockheed Aircraft	32 7/8	21	23
Magnovox	45	31 3/4	43 1/8
Mallory	47 1/8	40 1/2	43 1/2
Minneapolis-Honeywell	150 3/8	123 5/8	147 3/4
Minnesota Mining & Mfg.	188 3/4	161 1/4	185 1/2
Motorola	178	140	175 3/4
National Acme	54 3/4	49 1/4	50 1/4
National Cash Register	67	55 3/4	61 3/4
Neptune Meter	34 1/4	27 1/2	29 5/8
North American Aviation	41 1/4	30 1/2	32 7/8
Northrop Aircraft	30 3/8	24 3/4	28 1/8
Otis Elevator	42	36 3/4	39 3/4
Philco Corp.	38 1/4	26 3/8	33
Radio Corp. of America	78 3/8	59 1/2	77 3/4
Raytheon Mfg.	53 3/8	39 5/8	41 3/8
Reliance Electric	68 5/8	51	49 1/4
Rheem Mfg.	28 7/8	19 7/8	21
Robertshaw Fulton	55	47 1/4	48
Royal McBee	21 3/8	16 1/8	18
Sangamo Electric	44 1/4	37 3/4	41 1/2
Siegler Corp.	38 7/8	29 1/4	38 5/8
Sperry Rand	26 1/4	21 1/4	21 5/8
Square D	37 7/8	28 1/8	30 5/8
Standard Coil Products	17	12 3/4	13 3/4
Starrett (L.S.)	23 7/8	18	17 1/4 Bid 17 3/4 Asked
Steward-Warner	32 1/2	23	28 3/4
Talautograph	10 1/4	7 1/4	7 7/8
Texas Instruments	219 1/4	154	214 1/4
Thompson-Ramo-Wooldridge	57 7/8	46 7/8	55 1/8
Tung-Sol Electric	40 1/4	32 1/2	33 3/8
Underwood Corp.	32 3/8	24 3/4	27
Union Carbide Corp.	148 1/2	126 1/2	136
United Shoe Machinery	64 3/8	50	51 1/4
Varian Associates	50	39 3/4	51 1/2
Wallace & Tiernan	47 1/2	41	43 7/8
Western Union	57	43 3/4	44 3/8
Westinghouse Air Brake	32 5/8	26 3/8	28 3/4
Westinghouse Electric	57 1/4	45 1/2	54 7/8
Wortnington Corp.	66	50 1/2	55

(1) Not traded - Bid and Asked

These prices and price ranges are given as printed in the Wall Street Journal.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1960 THRU APRIL 18, 1960

	High	Low	Price As Of 4/18/60
American Meter	52	38	47 1/4 Bid 48 1/4 Asked
Aro Equipment	24 5/8	21 1/8	21 3/8
Barry Controls "B"	23 1/2	16 1/4	19 7/8
Belock Instruments	17 7/8	13 1/8	15 7/8
Benrus Watch	7 1/2	5 3/8	5 3/4
Breeze Corp.	8 5/8	6 1/2	6 7/8
Clark Controller	23 5/8	20	21

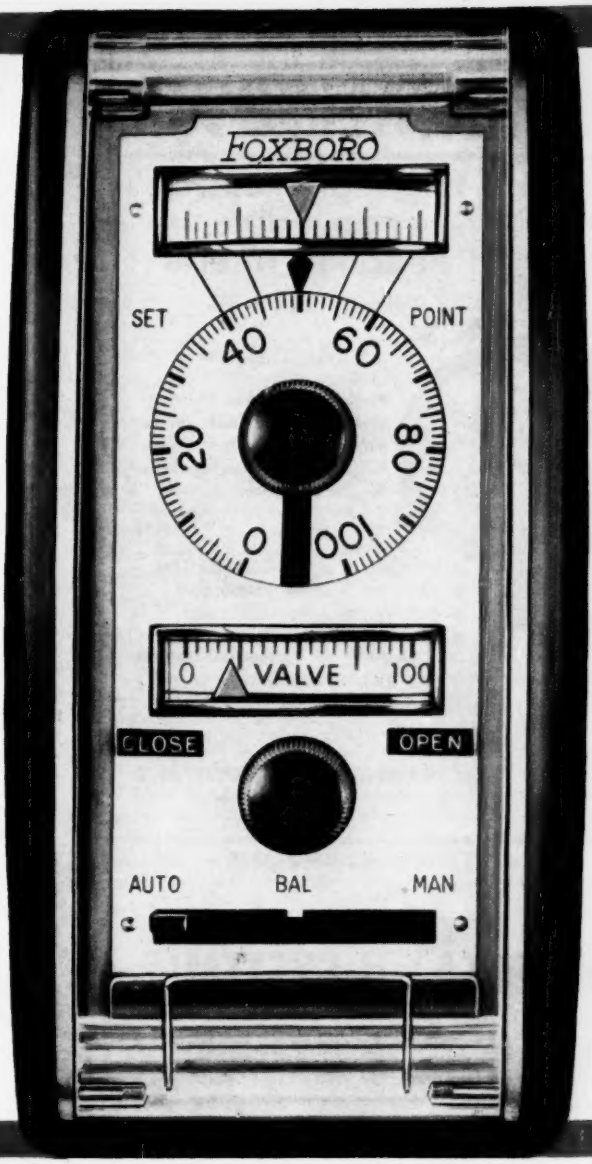
Continued on page 732

Measurement deviation...

plus indication...

plus valve position...

you get them all with this **Foxboro electronic control station**



Shown here actual size →

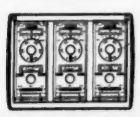
One 3" x 6" panel station containing all control and supervisory functions — that's the Foxboro Electronic Consotrol* Controller. All d-c input — all d-c output — all solid state. Operates completely independent from recording.

And look at these other features:

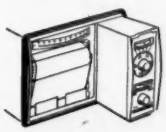
- measurement and deviation indicator gives continuous indication of process measurement as well as showing the deviation from set point.
- calibrated set point dial, with 4¾" scale, used with deviation indicator for readability of ½% full scale.
- valve position indicator for continuous, horizontal-scale indication of valve opening.
- simple auto-manual transfer switch for smooth, bumpless transfer.

Foxboro electronic Consotrol control stations are available for cascade, ratio and auto-selector systems. Ask your Foxboro Field Engineer about them — or write for Bulletin 21-10. The Foxboro Company, 465 Neponset Avenue, Foxboro, Massachusetts.

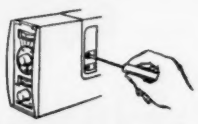
Reg. U. S. Pat. Off.



Standard 9" x 6" housing holds 3 control stations, or 1 station with a companion recorder.



Controller and recorder each slide out from panel for easy servicing.



Proportional — reset — derivative: all adjusted from the front.

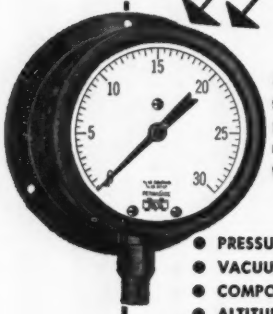
FOXBORO

REG. U. S. PAT. OFF.

CIRCLE 21 ON READER-SERVICE CARD

MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS



Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

- PRESSURE
- VACUUM
- COMPOUND
- ALTITUDE
- COMBINATION
- DIAPHRAGM
- HYDRAULIC
- AND SPECIAL PURPOSE GAUGES
- DIAL THERMOMETERS (Vapor Tension or Bi-Metal)

WRITE TODAY FOR COMPLETE INFORMATION

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

CIRCLE 22 ON READER-SERVICE CARD

ICS STOCK REPORT

continued from page 730

Clarostat Mfg.	15 7/8	9 7/8	12 1/4
Clary Corp.	10 3/8	6 3/4	8 1/8
Cubic Corp.	6a 7/8	4a 1/2	6a
Du Mont Laboratories	10	6 1/2	9 7/8
Dynamics Corp. of Amer.	13 3/4	10 3/8	10 3/4
El-Tronics	1 7/8	1 1/4	1 3/8
Electronics Corp. of Amer.	14 3/8	8 1/8	14 1/8
Fairchild Camera & Instrument	172 3/8	110 1/4	172 3/8
General Transistor	31 3/8	20 3/8	22 5/8
Globe-Union	34 3/4	25	32
Hazeltine Corp.	30 3/8	23	24 3/4
International Resistance	25 3/8	18 1/4	19 5/8
Loral-Electronics	47 3/4	34 5/8	42 5/8
National Research	23 1/8	16 1/8	17 1/2
New Haven Clock	2 7/8	1 7/8	2 1/8
Nuclear Corp. of Amer.	3 3/8	2 1/4	2 3/4
Philips Electronics, Inc.	41 3/8	31 1/2	34 3/4
Pneumatic Scale	59 3/4	40	41 1/4
Polarad Electronics	46 7/8	30 1/2	46
Servo Corp. of Amer.	24 1/2	16 1/4	16
Servomechanisms	12	8 1/4	8 1/2
Statham Instruments Inc.	35 1/2	27 1/8	30 3/4
Textron Electronics	15 3/4	11 1/4	15
Victoreen Instrument Co.	13 3/8	9 3/4	12
Waltham Prec. Instrument Co.	3 1/2	2 3/4	3

(1) Not traded - Bid and Asked

These prices and price ranges are given as printed in the Wall Street Journal.

OVER THE COUNTER

	Quotation As Of April 18, 1960	
	Bid	Asked
Aerovox Corp.	11 1/8	11 5/8
Argus Corporation	30 5/8	31 3/8
Black Sivalls & Bryson Inc.	16 1/4	16 3/4
Eitel Mc Cullough	33 1/8	35 5/8
Electro Instruments	47 1/2	48 1/2
Electronics Associates	27	28
Erie Resistor Corporation	8 7/8	9 1/4
Fisher Governor Co.	16 1/2	17 1/4
Foxboro Company (new)	39 1/4	40 1/4
Giannini Controls	42 3/4	43 3/4
Hagan Chemicals & Controls	37 1/2	38 1/2
Industro Transistor	10 1/4	11
Liquidometer Corp.	12	12 3/4
W. L. Maxson	12 3/4	13 1/2
Penn Controls	21 1/2	22 1/2
Speer Carbon, Inc.	19 1/2	20 1/2
Sprague Electric	60 1/2	62
Taylor Instruments	51 1/2	52 1/2
Telecomputing Corp.	9 1/2	9 7/8
Vitro Corp. of America	13 5/8	14

THE BETA* II SYSTEM

DIGITAL RESEARCH AND EDUCATIONAL TOOLS IN ADVANCE OF INDUSTRY AND COLLEGE NEEDS!

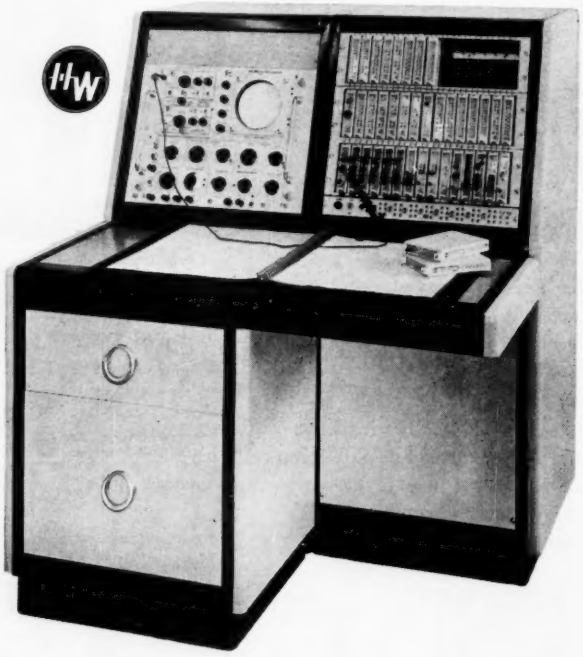
The Beta II system is designed to house the complete digital laboratory requirements in one station through the use of Data Bloc® units as modular components

These units are also particularly applicable for educational purposes through their proven reliability, economy, speed (5 MC), and versatility.

Laboratory time is at a premium in today's research and educational training programs where much energy is consumed by the breadboarding of basic circuits.

Pin jack front panel logic of Data Bloc® units permits the most efficient and reliable programming in digital work available today.

*(BASIC ENGINEERING TRAINING AID)

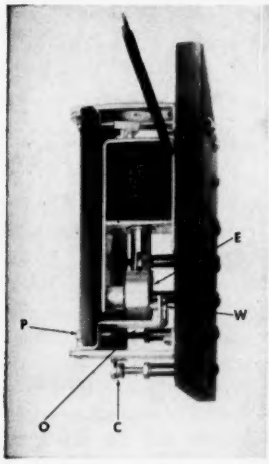


HARVEY-WELLS ELECTRONICS, INC.

14 HURON DRIVE • EAST NATICK, MASSACHUSETTS

CIRCLE 23 ON READER-SERVICE CARD

ASCO mechanically held relays are power driven in both directions with no dependency on springs or latches for operating or mechanically holding contacts

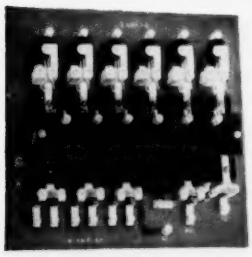


The Unique ASCO Mechanically Held Movement

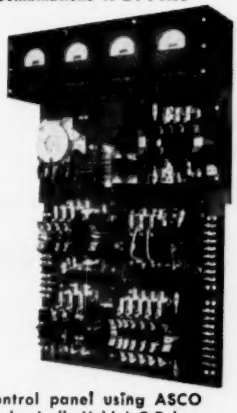
When the solenoid is energized, eccentric cam (E) is rotated. Weight drive pin (W) causes movement of operating lever (O). Lever (O) (connected to the contact finger block) rotates on pivot pin (P) and contacts such as (C) are opened or closed.

Note that with the solenoid de-energized, the entire mechanism is firmly locked in place by the angular position of the linkages—no springs, latches, or semi-permanent magnets are required!

ASCO Mechanically Held Relays A-C and D-C . . . to 25 Amperes Combinations to 24 Poles



Special ASCO Relay with 6 D-C Poles for 600 volts, 3 A-C Poles for 230 volts and 125 volts D-C control. Note Blow-outs on D-C Poles.



Control panel using ASCO Mechanically Held A-C Relays (Bulletin 1256-168). Notice multiple pole and double throw arrangements.

ASCO Power Driven Relays with No Springs or Latches:

- Provide higher contact pressures
- Minimize the possibility of contact welding
- Insure positive operation

Design simplicity is provided in ASCO Mechanically Held Relays through use of a single solenoid coil mechanism. The coil is momentarily energized during the instant of operation only. This momentary surge of power electrically operates the relay to *open and close* contacts; thus the relay is power driven in both directions, with no dependency on springs or gravity for operating and mechanically holding the contacts.

FEATURES

• No A-C hum or chatter • Operate in any position • Compact construction permits mounting on metal surfaces or panelboards • Operated by single-coil mechanism—positive in each direction • Silver contacts rigidly locked open or closed by angular relation of linkages—no delicate hooks or latches • Signal lamps require no extra contacts or control wires • Enclosed rating same as open rating due to liberal design and momentary mechanism without coil losses • All parts finished in cadmium plate or black to present good appearance and to match larger ASCO Switches.

APPLICATION

ASCO Mechanically Held Relays are used for automatic or remote control where A-C hum or chatter is objectionable, where coil loss is undesirable or where relays must not change position when the control circuit fails (low voltage release). ASCO Mechanically Held Relays are often used for master control of other control equipment, to prevent loss of voltage or control failure. These relays are frequently used for electric heaters, lighting, and similar applications.

Mechanically Held Relays are only part of the complete line of Relays made by ASCO. Our Catalog 57-S4 lists:

MAGNETICALLY HELD RELAYS
A-C or D-C . . . Normally Open . . . Normally Closed . . . Double Throw

ASCO Magnetically Held Relays use a physical arrangement which parallels that of ASCO Rocker Type Mechanically Held Relays. Since the two types are similar in appearance, they help to increase the attractiveness of control panels, at the same time offering interchangeability of contacts.

SPECIALIZED RELAYS

. . . Reverse Current
. . . Time Delay
. . . Brake Winding Time Delay
. . . Close Differential (Voltage and Current Types)
. . . Current Type, Welding
. . . Electronic
. . . Modified Arrangements

ASCO Electromagnetic Control

Automatic Switch Co. 52-F HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

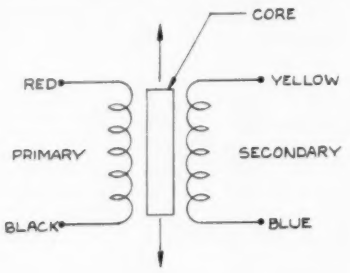
ASCO®

CIRCLE 24 ON READER-SERVICE CARD

BRIEFS

Linear Motion Transducer

The Collins Linear Transducer is a transformer in which the secondary flux linkages are a function of the linear displacement of a movable probe . . . Contrary to ideal transformer theory, the secondary out-



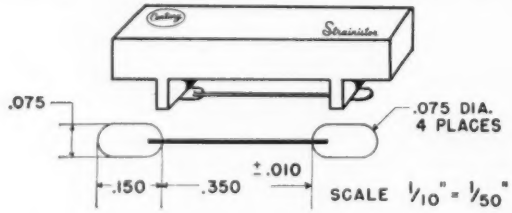
put impedance is constant throughout the stroke. The Design is such that the change in impedance due to transformer ratio is exactly compensated by the change in secondary leakage inductance . . .

In defining the quality of performance, phase shift is secondary only to linearity. In control components carrier phase shift can cause erratic performance or the complete malfunction of a servo system . . . Units are available in ¼ to 2 inch diameter pickoffs and varying in length from ½ inch to 12 feet . . . (*From new General Catalog containing 4-page bulletin and 24 typical specification drawings, G. L. Collins Corp., 2820 East Hullett St., Long Beach 5, Calif.*)

FOR THIS LITERATURE CIRCLE 183 ON READER-SERVICE CARD

Ultra-sensitive Strain Sensing

The Model 711 Strainistor has ultra-sensitive strain sensing elements with 60 to 70 times greater sensitivity (120-140) than other metal strain gauges, 120-ohm nominal resistance, negligible hysteresis, resistance

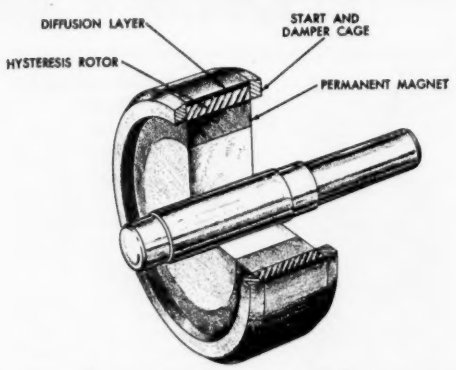


change linear with strain . . . The change in resistance can be measured by simply measuring the resistance before and after the load and subtracting. The Strainistor can also be used in a conventional bridge or potentiometer circuit . . . (*From new 2-page Brochure CEI-900, and 4-page Instruction Bulletin CEI-901, Century Electronics & Instruments, Inc., Box 6216, Pine Station, Tulsa 10, Okla.*)

FOR THIS LITERATURE CIRCLE 184 ON READER-SERVICE CARD

Synchronous Hysteresis Motor

When the switch is closed the motor starts with the vigorous torque of an induction motor. The AC flux passes through the hysteresis rotor and does not penetrate into the permanent magnet. The motor ac-

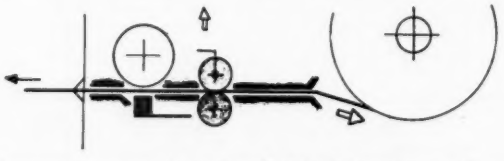


celerates rapidly up to about ¾ of synchronous speed. From there the induction motor torque decreases, but the hysteresis torque continues at a constant value accelerating the rotor at a slighter but steady rate up to synchronous speed. Just under synchronism when the poles of the permanent magnet and the stator field are lined up, the flux and the torque increase and the rotor pulls into synchronism. Once in step, the motor operates as a permanent-magnet-excited synchronous motor . . . (*From new 6-page brochure "The Hypersyn Motor," Bekey Electric, Div. of Genisco Inc., 2233 Federal Ave., Los Angeles 64, Calif.*)

FOR THIS LITERATURE CIRCLE 185 ON READER-SERVICE CARD

Printing Impulse Counter

In its simplest form, the "Sodeco-Print" is an impulse counter with electrical reset, having also a mechanism for printing the reading on a paper chart or ticket simply by operating a push button . . . An



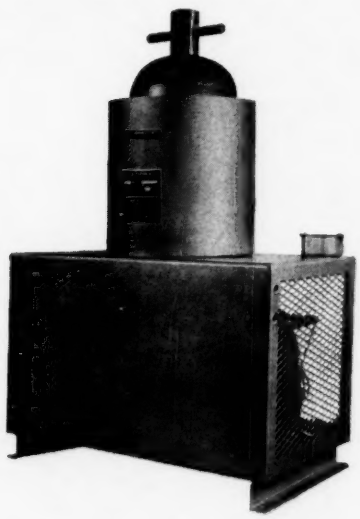
electromagnet receives the electrical impulses and, at the moment the armature is attracted, advances the figure drums. Each impulse causes the unit drums of the counter and the printing mechanism to advance simultaneously by one unit. At each tenth impulse, each figure drum advances the preceding one by one step.

Operation of the electrical pushbutton situated on the lower part of the front panel of the printer, or a separate pushbutton mounted at a distance, energises another electromagnet, the armature of which carries a hammer. The latter presses the paper chart and the inked ribbon against the figure drums of the printing mechanism . . . (*From new 12-page Bulletin E62 Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.*)

FOR THIS LITERATURE CIRCLE 186 ON READER-SERVICE CARD

New "Packaged" Protection for Pneumatic Systems

Meet the F-30 ■ **Non-clogging trap saves money ○** **Refrigerate for driest air ●**



■ "Packaged" Protection, Jr.

That's the new Hankison Model F-30 Refrigifilter, designed to give *medium capacity* pneumatic systems microclean, dehydrated, oil-free compressed air . . . protect them from the rust and sludge conditions that lead to malfunction and equipment failure. It's rated at 30SCFM, gives you a dew point as low as 40°F *at pressure*. Like its older brother, the F-100, it requires no cooling water, eliminates problems caused by ambient temperature variance. Pressure drop across the unit does not exceed 1½ PSIG.

The new F-30 combines the functions of a condenser, separator, filter, and trap (internal or external), in a package just 35″ high. It discharges *cool*, dry air—exit air temperature is 52°F at rated capacity and 75°F ambient temperature.

Ask today for the full story—just use the coupon at right.

○ The Finish Started It All

One of the world's leading manufacturers of laboratory furniture is particularly noted for his handsome, long-lasting surface finish, sprayed on with meticulous care. Water in their air lines is intolerable—and of course, very expensive in terms of refinishing costs. The answer seemed to be a condensate trap, but none of several tried could handle the emulsified oil from the compressor, without plugging up. Then, about two years ago they started to use a Hankison Mag-Pneu-Power Automatic Trap. The result? They're getting "perfect service" to use the Plant Engineer's words, and their Mag-Pneu-Power Trap has never required other than routine attention.

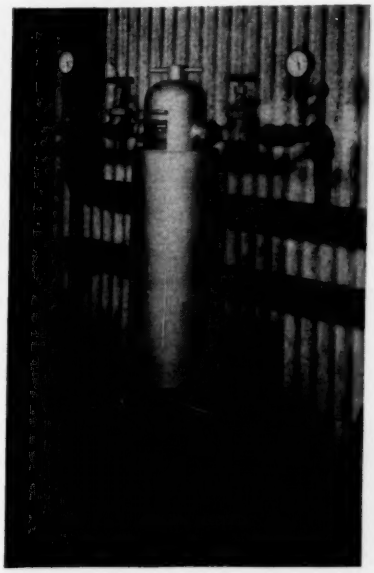
Hankison Mag-Pneu-Power Automatic Traps use the actual pressure in your pneumatic systems to accomplish split-second discharge. A large, ½″ orifice accounts for their non-clogging feature, and for the occasional cleaning that's required, you simply open a blowdown petcock in the housing. They are used to discharge condensates and entrainments from all types of compressed air and gas lines, and to lend valuable assistance to air and gas dehydrating equipment. Stainless steel models are available for corrosion applications.

The coupon below will bring you full information.

● Refrigeration Air Drying Rated Superior by the Experts

Authorities on pneumatics say that the best air cleaning and drying is done by mechanical methods, and that the best mechanical methods base their efficiency on refrigeration.

Of all methods employing refrigeration, we maintain that Hankison Refrigifilters are unsurpassed, for these reasons: They are compact, completely integrated, ASME Coded "packages" employing closed-loop refrigeration cycles to obtain their low dew points and to eliminate problems of ambient temperature variance and need for cooling water. Condensate—oil and moisture vapor as well as entrained liquids—is discharged through the Mag-Pneu-Power Trap. Solid contaminants are removed by the specially-designed filter cartridge.



Refrigifilters are available in two models—the new F-30, described at left, and the F-100, (shown above, installed) which delivers—30°F atmospheric dew point, has a rated operating pressure of 300 PSIG.

For full details on the F-100, use the convenient coupon below.

HANKISON CORPORATION, COLLEGE & PIKE, CANONSBURG, PA.

Tell me more about Hankison products. Specifically, I want information on

- ☐ F-30 Refrigifilters
- ☐ Mag-Pneu-Power Traps
- ☐ F-100 Refrigifilters

NAME_____ TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

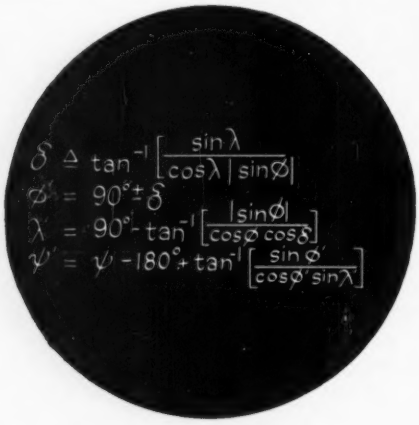
Hankison

FOR F-30 REFRIGIFILTERS, CIRCLE 25 ON READER-SERVICE CARD
FOR MAG-PNEU-POWER TRAPS, CIRCLE 26 ON READER-SERVICE CARD
FOR F-100 REFRIGIFILTERS, CIRCLE 27 ON READER-SERVICE CARD

ICS BRIEFS

32-lb Computer

Libratrac-2000 is a general purpose digital computer incorporating advanced logical design techniques, providing a computer with the highest degree of reliability and versatility in a minimum of space. Libratrac-2000 solves complex control problems . . .



It is equally efficient when utilized in contemporary aircraft such as long-range jet transports and can be employed in commercial and industrial applications as a data processor and control computer. The entire computer weighs only 32 pounds and occupies less than half a cubic foot in volume. Despite its extremely small size, Libratrac-2000 has the problem solving capability of computers many times its volume and weight and has a flexible memory system of 2048 words . . . (*From new 12-page bulletin, Librascope, Div. of General Precision, Inc., 808 Western Ave., Glendale 1, Calif.*)

FOR THIS LITERATURE CIRCLE 187 ON READER-SERVICE CARD

Common Abbreviations in Ham Usage

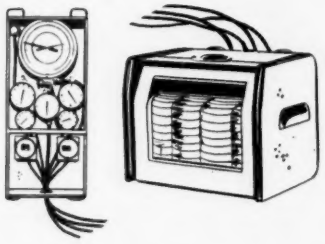
ABT	About	GM	Good morning
AGN	Again	GN	Good night
AMP	Ampere	GUD	Good
ANI	Any	HAM	Amateur
BCNU	I'll be seeing you	HI	Laughter
BK	Break	HR	Hear, here
BTR	Better	HRD	Heard
CRD	Card	HV	Have
CUD	Could	HW	How
CUL	See you later	NIL	Nothing
DX	Distance	NR	Number, near

(*From new 4-page pamphlet "Short Course for Novice License," containing 33 questions and answers and entire Morse Code, Popular Q Signals, ARR Word List for Radiotelephony, etc., Electronic Instrument Co., Inc., 33-00 Northern Blvd., Long Island City 1, N. Y.*)

FOR THIS LITERATURE CIRCLE 188 ON READER-SERVICE CARD

Electric Drilloger

The pressure signals of weight, pump pressure, and torque are taken from the indicating Martin-Decker gauges or some component of the system and converted through a transducer to an electric signal . . .



The signal can be carried through as much as two miles of electric cord without requiring amplification. . . . The Martin-Decker Drilloger is generally mounted in the doghouse or toolpusher's office . . . One of the outstanding advantages is ability to calibrate any signal to almost any practical scale, including a zero offset for expanding the chart at high ranges of operation . . . (*From new 4-page Bulletin P-90A Martin-Decker Corp., Long Beach, Calif.*)

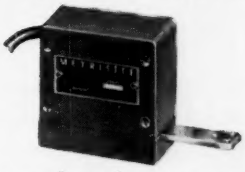
FOR THIS LITERATURE CIRCLE 189 ON READER-SERVICE CARD

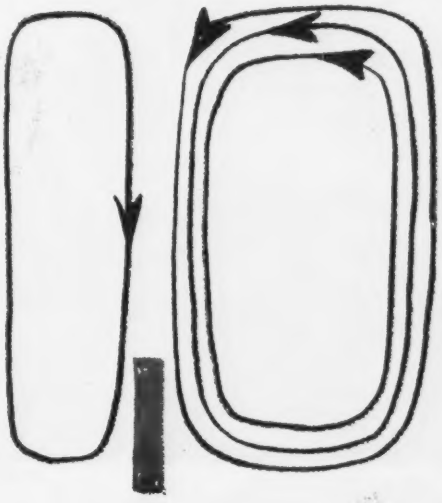
Multirange Digital Voltmeter

The BH190 Portable Voltmeter is a digital indicating instrument with accuracy previously available only in laboratory equipment. The unit is a continuous null balance slide-wire potentiometer with a simple and direct analog-to-digital conversion system . . . The 144-inch Mylar tape that carries the slidewire em-

bedded in its edge is mounted on two spools as is motion picture film. During automated electronic calibration the tape is perforated according to code markings contained on a master tape 60 feet long, against which the tape being calibrated is compared in a servo bridge network . . . Digital indication is accomplished by gearing an in-line counter to the sprocket wheel drive shaft . . . The Voltmeter is accurate to 0.1% of its range in normal ambient temperatures. (*From new 4-page bulletin, B&H Instrument Co., Inc., 3479 West Vickery Blvd., Fort Worth 7, Texas.*)

FOR THIS LITERATURE CIRCLE 190 ON READER-SERVICE CARD

Metrisite...is the only device available today that provides a near-perfect combination of ideal transducer characteristics. The unusual properties of this remarkable new motion-sensing development are: extreme resolution...  easily measures one ten-millionth of an inch; minute operating force...absolute minimum bearing friction; negligible reactive force... a fraction of a milligram; true linearity...a proven accuracy of 1/10%; high electrical output...up to 100 volts without amplification; wide range of shapes and sizes...from sub-miniature on up; exceptional ruggedness...can meet military shock and vibration tests. Now, many of the obstacles that have plagued control technology can be eliminated. Write for Metrisite details.



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DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

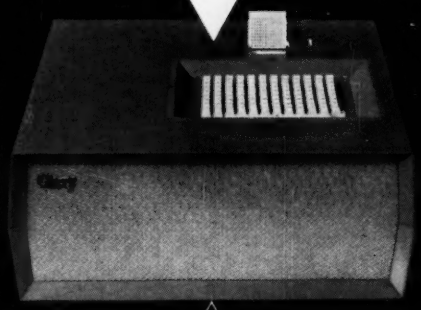
CIRCLE 28 ON READER-SERVICE CARD

NEW CLARY SCANNING PRINTER ACCEPTS

BOTH DECIMAL AND CODED DATA...

ON SAME LINE...AT NO EXTRA COST...

from digital voltmeters, shaft position transducers, electronic counters, EPUT meters, step switch banks, relay banks, selector switches, digital clocks ...draws negligible power from these sources...



...and color-prints in black and red at three lines per second, with a capacity of 12 digits per line. Full manual keyboard is standard. For more information on the Clary Model 1961 Scanning Printer, write today for Engineering Bulletin No. S-111.

Clary ELECTRONICS DIVISION
CLARY CORPORATION
San Gabriel, California

CIRCLE 30 ON READER-SERVICE CARD

CIRCLE 31 ON READER-SERVICE CARD →

when you're considering control valves, it pays to look at the whole picture!

How do you buy control valves? On price? On the basis of quality of materials and craftsmanship? On flow capacity, sensitivity or other performance characteristics? Sure, these are all important considerations. But no one of them *alone* offers a sound basis for evaluating control valves. You should take into account all of these factors, and many more . . . the whole picture.

A control valve is more than just hardware. It's actually the payoff point of your process. That's why it pays to consider other Honeywell factors, beyond the valve itself—things like process control experience, application engineering, and installation and maintenance supervision. The "whole picture" approach rewards you with best possible valve performance and better processing, regardless of your application.

IF YOU'RE CONSIDERING CONTROL VALVES, STUDY THE HONEYWELL PICTURE FROM EVERY ANGLE . . . YOU'LL FIND IT A BRIGHT ONE.

here's how Honeywell brightens the

Honeywell puts 75 years of control experience to work for you

Honeywell control valve know-how is the first big step in solving flow problems related to hard-to-handle fluids . . . corrosion . . . high and low temperatures. It's experience that started 75 years ago with the application of simple controls to simple processes. Today, this background helps put control valves to work in nuclear energy, missiles, industrial processing, utilities, and other areas.

Honeywell field engineers think in terms of the "whole picture"

Honeywell field men are more than just valve specialists. They're control engineers. Because they work with valves in their relation to the *overall* control system, they can help you get the very best from your entire system.

These eight control valves are representative of the broad Honeywell line.

Versatile, inexpensive . . . for general plant or process flows.

Self-contained, electric motor actuated . . . for plant service applications.

Tight-closing, Saunders type . . . for slurries or other hard-to-handle flows.

Small inner port area assures precise control of small flows in laboratory and process.

FREE VALVE DATA. The above valves, and many more, are described in our 84-page catalog. You'll find it a valuable [illegible] . . . including data on flow characteristics, [illegible] other useful information. Write today; [illegible]

control valve picture for you!

Honeywell application engineers find the answers

The application engineers who back up our field men are experienced in tackling the toughest control problems. They study your flow conditions, performance requirements and potential trouble spots—and find the right answers in terms of correct control valve application.

Honeywell builds extra quality into control valves

Each Honeywell control valve is the product of first-rate materials, precision machining, careful assembly, and the most rigid testing and inspection imaginable. You can rely on them for long, low-maintenance service—and, for all their ruggedness, they're built to operate with the precision of a fine instrument.

Honeywell delivers on time

You'll like the completeness and "on-time" aspects of Honeywell service. Each order is double-checked against your final process requirements before it's shipped. Stocks of the most commonly used valves and parts are always kept on hand, ready to meet your deadlines.

Honeywell helps install and maintain your control valves

Your local Honeywell service engineer can lend you an experienced hand in installation and startup of your system. Honeywell control valves rarely require any more maintenance than an occasional check of the packing box. But should any trouble arise, a call to your Honeywell branch will bring help on the run.

Split-body simplifies maintenance in control of "problem" fluids.

Balanced, three-way operation . . . ideally suited to mixing or diverting.

Special features and accessories . . . for high temperatures and pressures.

Angle-body, electro-pneumatic positioning . . . exemplifies flow and control versatility.

75th YEAR

we'd like to start working for you right now

HERE'S THE VERY FIRST STEP TOWARD BETTER CONTROL

Fill in this coupon and return it to Honeywell's Valve Division

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
VALVE DIVISION, Fort Washington, Pa.

Please send catalog. I am interested in Control Valves for

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Name_____ Title_____

Company_____

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City_____ Zone____ State_____

Put our team of experts to work on your control valve problems right away. You'll find that Honeywell's Valve Division is a reliable source of competent engineering assistance and excellent products. Tell us about your application today.

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY,
Valve Division, Fort Washington, Pa.

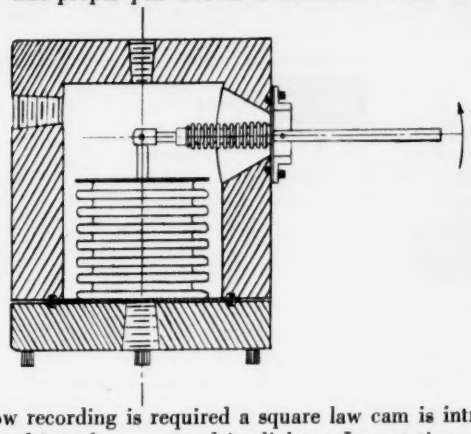
Honeywell

First in Control

SINCE 1885

Single-bellows Flowmeters

Differential pressure developed by the primary element (orifice or flow nozzle) is sensed by a metallic bellows and converted to relatively linear motion. This motion is opposed by an external calibrating spring so that proper pen motion is obtained. When linear

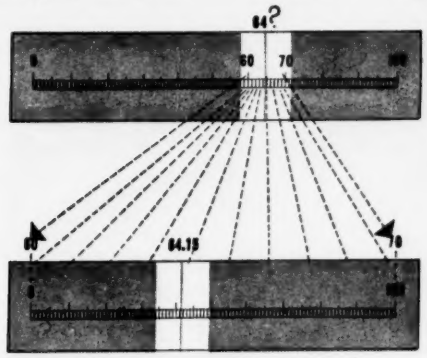


flow recording is required a square law cam is introduced into the pen arm drive linkage. Low static pressure flow measurements (under 10 PSI) are made by a slack diaphragm sensing element which is used in place of the differential pressure cell. The single-bellows feature has several advantages . . . (*From new 2-page Bulletin FM-2-60, Optimum Control Corp., West 49th at Denison, Cleveland 2, Ohio.*)

FOR THIS LITERATURE CIRCLE 191 ON READER-SERVICE CARD

Scale-Expansion Meters

A current of under-100 microamperes is to be checked. You set the range switch for 0 to 100 scale. Let's assume this sampling reads about 64 microamperes. Next-flip the Expander switch. The selected bandwidth of 60 to 70 microamperes opens up wide to encompass the FULL 6.3 inch scale . . . Now you



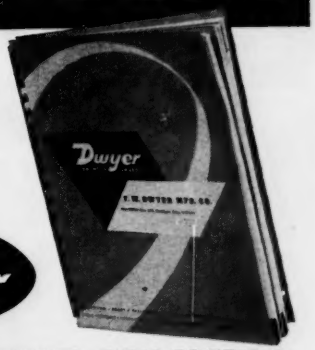
would be reading it as a precise 64.15 microamperes. The decimal system usually makes it convenient to provide for expanding TEN equal sections—EACH into full scale. However, the factory can provide any other arrangement within reason—whether more or less than 10 sections . . . In effect, the meter can provide a total equivalent of a 126-inch 2000-division scale . . . (*From new 20-page Bulletin "Precision Meters," Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y.*)

FOR THIS LITERATURE CIRCLE 192 ON READER-SERVICE CARD

←CIRCLE 31 ON READER-SERVICE CARD

NEW GAGES NEW IDEAS

IN THE 1960



Dwyer

INSTRUMENT MANUAL

Need a meter for *direct* reading of both air velocity and static pressure? An inexpensive gage that tells homeowners when to change air filters? A complete, accurate combustion test kit, or a manometer that *rolls* up to fit compactly in your tool box? You'll find these and many more money-saving ideas described in this free Dwyer manual. It's packed full of valuable information about Dwyer's complete line of instruments.

- **Magnehelic Gages** . . . velocity, resistance, draft, static and gas pressure.
- **Inclined Tube Gages** . . . draft, velocity, slight pressure variations.
- **Air Filter Gages** . . . models for every installation.
- **Hook Gages** . . . a true low pressure calibration standard.
- **Air Velocity Meters** . . . direct reading of air velocity and static pressure.
- **Flowmeters** . . flow measurement of gas
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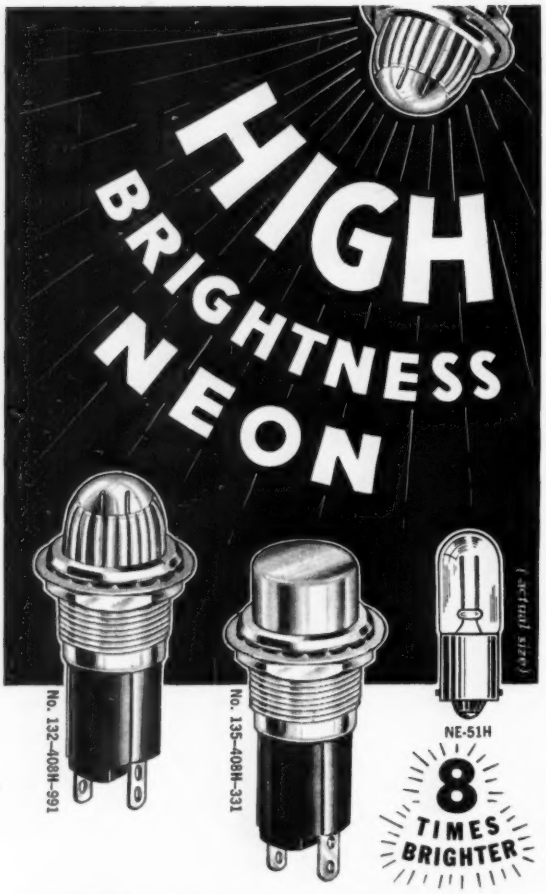
CIRCLE 32 ON READER-SERVICE CARD



DIALCO® PILOT LIGHTS

with Built-in Resistor

(a patented DIALCO feature)

for the Neon Glow Lamp NE-51H (High Brightness)

RUGGED: The NE-51H Neon Glow Lamp is made to resist vibration and is proof against sudden failure. It may be operated at about 3 times the level of current applied to the standard neon lamp, and it will produce 8 times as much light—*with long life!* Requires low power—less than 1 watt on 250 V circuit. Recommended for AC service (may be used on DC circuits above 160 V).

BUILT-IN current-limiting resistor (U.S. Patent No. 2,421,321): For use on 105-125 volt and 210-250 volt circuits. In DIALCO Pilot Lights, the built-in resistor is completely insulated in moulded phenolic and sealed in metal.

COMPACT: Units are available for mounting in 9/16" and 11/16" clearance holes... in a wide choice of lens styles and colors, terminal types, metal finishes, etc. Meet applicable MIL Spec and UL and CSA requirements.

Every assembly is available complete with lamp.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Ask for Bulletin No. 100 and Catalogue L-161B.

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

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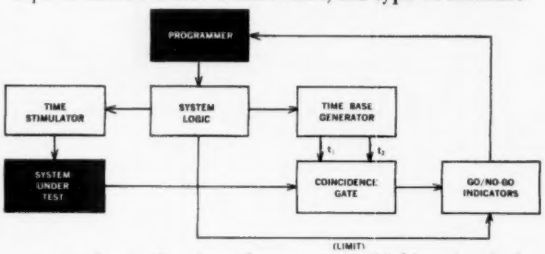
CIRCLE 33 ON READER-SERVICE CARD

Universal Control and Test Equipment

Basically, the UACTE consists of electrical measuring devices and voltage reference sources that are capable of being interconnected in order to evaluate functional parameters of a known given circuit. Eighty bits of binary information can be programmed on tape to establish interconnections, the type of measure-



ment to be made, the tolerances to which a circuit is to be evaluated, and control information.

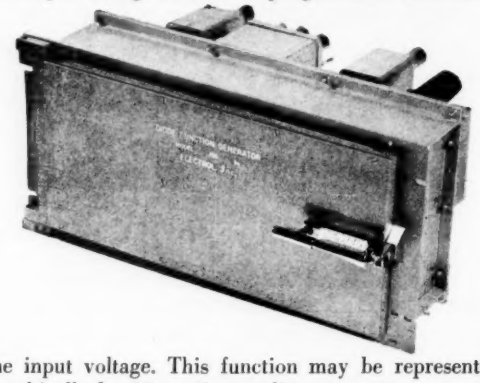
The crystal controlled clock referred to as the timing generator initiates a gate after a programmed period. This programming capability allows a time measurement and comparison to be made at some preselected period from 0.1 to 100 seconds.

The UACTE has the capacity to perform a vast number of functions. Space and logic have been provided to accommodate particular needs of industry. Direct digital output is available to operate a commercial type printer, if a record of the test results is desired . . . (*From new* 16-*page Technical Bulletin* 829903, *Pacific Automation Products, Inc.,* 1000 *Air Way, Glendale, Calif.*)

FOR THIS LITERATURE CIRCLE 193 ON READER-SERVICE CARD

Card-Programmed Function Generator

Model 100 . . . utilizes computing amplifiers, silicon junction diodes and precision resistors to generate an output voltage which is a programmed function of



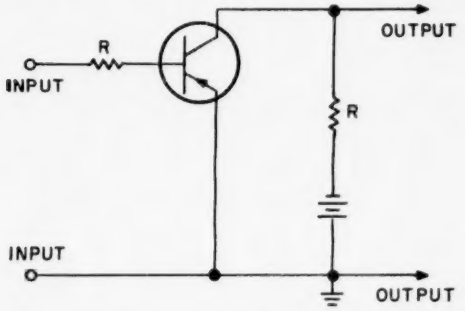
the input voltage. This function may be represented graphically by 20 contiguous line segments.

The punched card memory of the Model 100 enables pre-programming and therefore eliminates costly idle time on the entire computer facility while programming non-linear functions . . . (*From new* 2-*page pamphlet General Computers, Inc., Box* 1152, *Beverly Hills, Calif.*)

FOR THIS LITERATURE CIRCLE 194 ON READER-SERVICE CARD

NOR Circuitry

Basic NOR circuitry embodies a p-n-p junction transistor operating in the standard grounded emitter configuration. The transistor has its collector electrode connected to a grounded bias supply through a current-limiting resistor. A second resistor in series with the base electrode supplies a current to



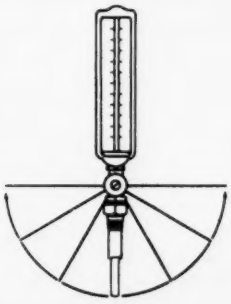
base when a voltage is applied to the circuit input. If this voltage is applied above a certain predetermined magnitude, and of the proper polarity, it will switch the transistor from its normal cutoff condition to a state of saturation.

When cut-off, the transistor acts essentially as an open circuit and, since the few thousand ohms involved is small compared to this open circuit, the voltage of the series resistor approximates the supply voltage and can be used for driving successive similar stages . . . (*From new 12-page Bulletin "Radilogs," Radiation, Inc., P. O. Drawer 37, Melbourne, Fla.*)

FOR THIS LITERATURE CIRCLE 195 ON READER-SERVICE CARD

Adjustable-angle Industrial Thermometers

This instrument is so designed that the stem of the thermometer can be tilted or rotated to any angle to provide ease of scale reading and eliminate parallax



error. A screw and nut adjustment positively locks the thermometer into the desired position either before or after installation . . . (*From new 8-page catalog 400, Moeller Instruments, Richmond Hill 18, N. Y.*)

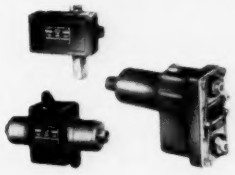
FOR THIS LITERATURE CIRCLE 196 ON READER-SERVICE CARD

CONFIDENCE

where control

counts

Pressure-Vacuum Controls for Industrial, Aircraft, Marine, Special Purpose



APPLICATIONS: Unlimited. For 28 years, we have been designing and manufacturing controls to fit individual needs.

MEDIUM: Air, gas or liquid.

RANGE: 30"hg vac to 1700 PSI.

SENSITIVITY: 3/4 ± 1/10" W.C. and up.

SWITCHES: Normally closed, open or double throw. Manual reset, high ambient and others available. 15 or 20 amps. 115/250 Volts AC. Also DC.

TYPES: Skeleton or enclosed, calibrated or uncalibrated, single or multi-switch, minimum size and weight, differential pressure, absolute pressure, super-sensitive, shock-proof, explosion-proof and others.

OPERATION: Precision-made bellows combine with full rated snap-action switches for quick accurate response to pressure or vacuum change.

For further information request Condensed Catalog #500.

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CONTROLS COMPANY

88 School St., Watertown, Mass.

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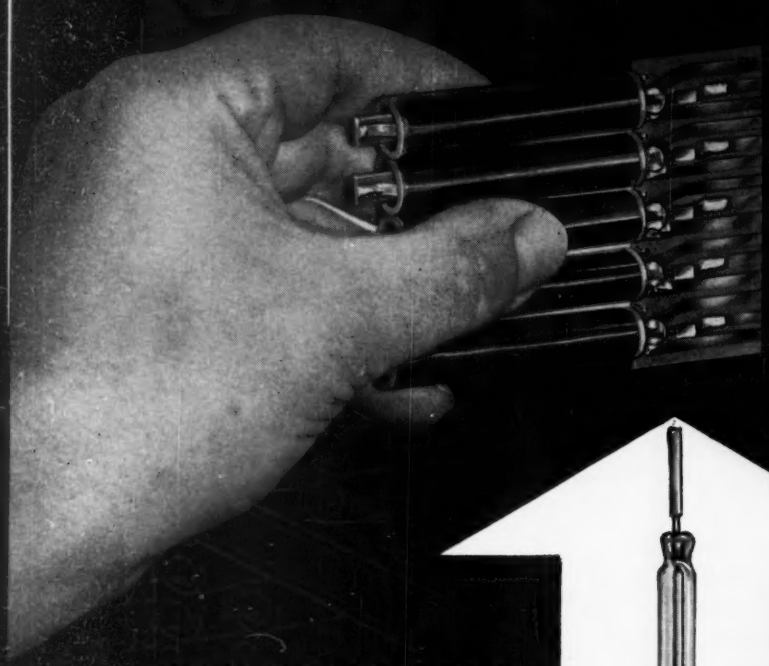
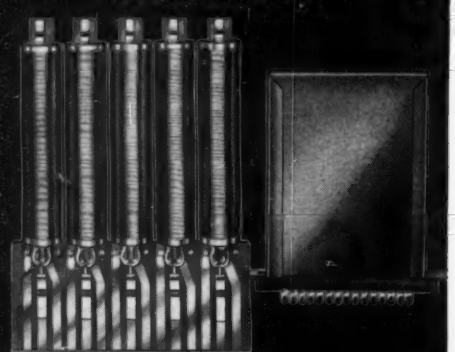
CLAREED®

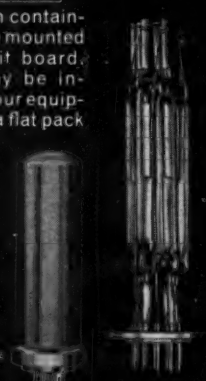
FITS INTO *YOUR* DESIGN!



PACKAGED TO MEET YOUR REQUIREMENTS



Here five relays, each containing two switches, are mounted on a printed circuit board. This assembly may be inserted directly into your equipment or enclosed in a flat pack container.



These six switches are clustered to form the core of a single electromagnetic coil, and encased in a cylindrical steel container.

ACTUAL SIZE

Basic element of CLAREED relays is this switch capsule. A pair of magnetically operated contacts is hermetically sealed in an atmosphere of inert gas. The capsule combines extreme simplicity with high reliability and long life. It has excellent low-level characteristics.

CLAREED Sealed Contact Reed relays put you . . . the designer . . . in the driver's seat. They are simple in design, flexible in assembly. They are packaged and mounted to comply with *your* mechanical design configuration . . . even on your own circuit board. CLAREED relays are ideal components for transistor-drive applications, computers, data-processing and other high speed equipment.

Contacts are hermetically sealed in inert gas. Tens of millions of operations are assured since contact contamination is completely precluded. Hundreds of millions of operations are possible when operated up to ½ rated load.

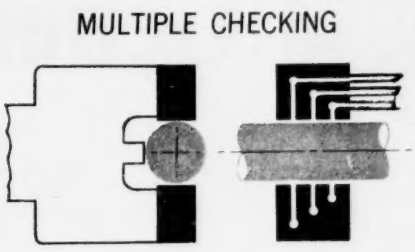
If you use relays, it will pay you to know all about CLAREED . . . an entirely new concept in relay design. Address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC-5.*

CLARE

When only the best is good enough

Air Gaging

The great dollar benefit of air gaging, even on small lots, is that operators with a few hours training can air gage parts faster and more accurately to any required tolerance than skilled inspectors can with other methods. You scrap fewer parts due to measuring error, and you save more parts which are reworkable. Air gaged products assemble faster, fit better, and reduce customer complaints . . . (*From new* 52-*page Catalog SPG*-160, *Sheffield Corp., Dayton* 1, *Ohio.*)

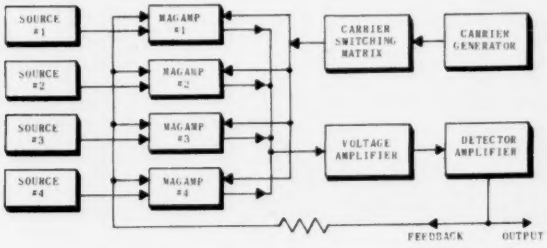


Airsnaps can be engineered for simultaneous inspections of diameters at several points.

FOR THIS LITERATURE CIRCLE 197 ON READER-SERVICE CARD

Magnetic Multiplexer for the Commutation of Low-level Signals

The new MAGNE-PLEXER samples output voltages of thermocouples, strain gauges, and other low level sensors wihtout the use of external pre-amplifiers. It is capable of handling several thousand sensors as a single system, and its speed can match the fastest voltage encoders. (Commutates at rates to 50 kc).



Each channel is connected to a novel subminiature magnetic amplifier having low noise, high gain, and excellent stability against drift. . . Carrier current is supplied to only one magamp at a time, under the control of the carrier switching matrix. Since zero E.M.F. is developed in the output windings of all of those magamps which are not receiving carrier current, the outputs may be connected together, amplified, and detected to provide the final output voltage . . . (*From new* 6-*page bulletin, San Diego Scientific Corp.,* 3434 *Midway Drive, San Diego* 10, *Calif.*)

FOR THIS LITERATURE CIRCLE 198 ON READER-SERVICE CARD

Checklist for Progress, Yours and Ours

✓	**GROWTH**—in General Electric's process instrumentation program, closely tied to growing field of industrial automation and related technologies.
✓	**PRODUCT DIVERSITY**—work on wide range of products to satisfy continuing needs of many industries for complex sensors, controllers, recorders, other electronic devices and systems.
✓	**CREATIVE DIVERSITY**—development of fundamentally new primary detectors, including means for sensing pressure and flow requires new technologies. Basic broad nature of measurements closely related to industrial growth.
✓	**CRITICAL POSITIONS**—opportunities to make significant contributions and receive high-level recognition in important project vital to General Electric objectives.

IMMEDIATE OPPORTUNITIES

TRANSISTOR CIRCUIT ENGINEERS—to develop and design millivolts to milliamps transducers for low level signals (e. g. thermocouple output), servo amplifiers for recorders, function generators for controllers, etc., B. S. in E. E., with experience in transistor circuitry and preferably industrial instrumentation.

EVALUATION ENGINEERS—to establish and conduct process instrumentation component and systems evaluation program. Determine data, specify facilities, establish procedures, analyze and interpret data, recommend product specifications. B. S. in E. E., experience in design and application of transducers, controllers, recorders.

MECHANICAL ENGINEERS—for design of transmitters involving diaphragms, bellows, Bourdon tubes. B. S. in M. E., 5 years in design of differential pressure and flow detectors.

RECORDER DESIGN ENGINEERS—to establish specifications for electronic amplifiers, apply latest miniaturization techniques, assure adequacy of overall system performance (accuracy and speed of response). B. S. in E. E., with experience in design of progress instrumentation recorders or similar electro-mechanical, servo-operated instrumentation equipment.

For further information, please write in confidence to: Mr. H. E. Crabtree, Manager, Engineering Administration,

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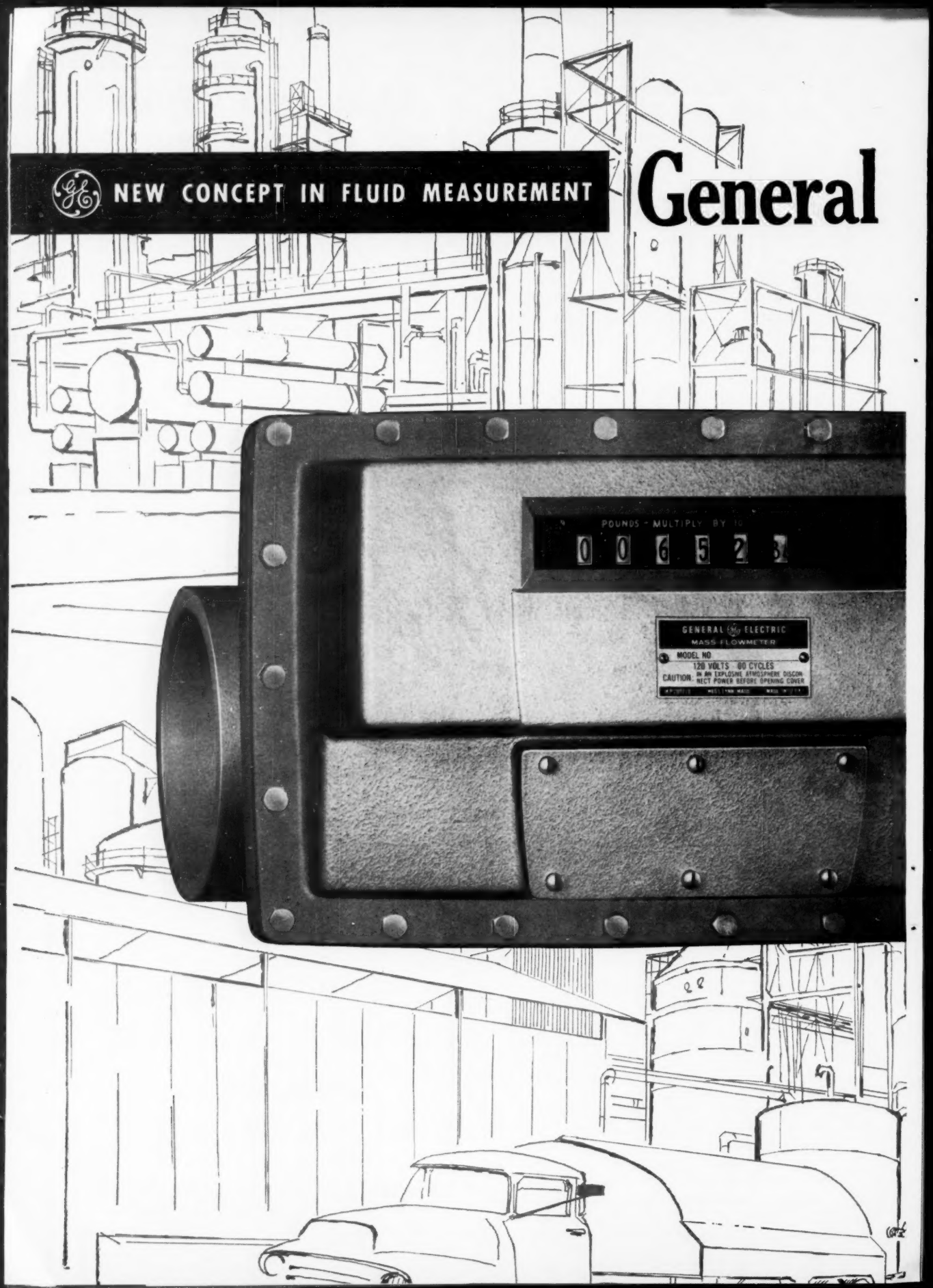
INSTRUMENT DEPARTMENT

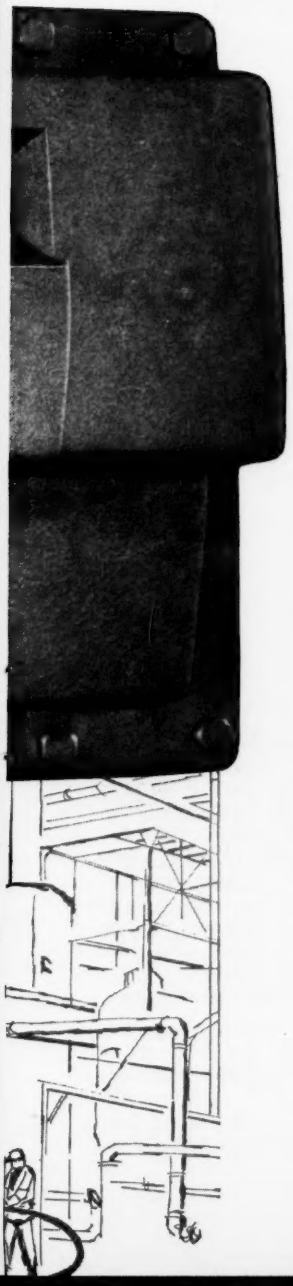
GENERAL ELECTRIC

46 Federal Street, West Lynn 3, Mass.

Progress Is Our Most Important Product


NEW CONCEPT IN FLUID MEASUREMENT
General
POUNDS - MULTIPLY BY 10
0 0 6 5 2 3
GENERAL ELECTRIC
MASS FLOWMETER
MODEL NO
120 VOLTS 60 CYCLES
CAUTION: IN AN EXPLOSIVE ATMOSPHERE DISCONNECT POWER BEFORE OPENING COVER

Electric Gyro-Integrating True Mass Flowmeter



ACCURATELY MEASURES FLOW OF LIQUIDS, GASES AND LIQUEFIED GASES . . . DIRECTLY IN POUNDS

This new General Electric meter provides continuous local or remote totalization and registration of gas and liquid flow by weight within ±1 percent accuracy over wide variations in flow rate, density, pressure, temperature and viscosity.

PROCESS FLOW MEASUREMENT—Ideal for applications in the petroleum, chemical, and petro-chemical industries, the new mass flowmeter completely eliminates time-consuming orifice calculations and possible costly errors in correcting volumetric readings for fluid variables. It does away with the need for recalibration when process and flow conditions change, too. And it puts an end to supercompressibility problems.

What's more, the new flowmeter lets you make complete and accurate material balances easily because it operates on a mass measurement principle and gives you your answer *in pounds*. No more measuring liquids in gallons or barrels, gases in cubic feet, then making tedious conversions in order to equate the two. Measurement of both by weight allows direct comparison.

LIQUEFIED GAS MEASUREMENT—You can measure the weight of truck and tank car loading of your liquefied gas products easier and faster with General Electric's new mass flowmeter than with present volumetric-type meters or expensive and cumbersome scale installations. The meter registers the total loaded weight directly in pounds. Then, operating from a battery-inverter power supply, the flowmeter can be used right on your truck when unloading, for easy and accurate deliveries. And no precautions are necessary to protect the meter from high velocity caused by "flashing."

An outgrowth of General Electric research into mass flow measurement, this new meter has already been proved on such fluids as natural gas, ethylene, Freon, liquid carbon dioxide, naphtha and jet fuel.

For complete sales and service information, contact your nearby General Electric Apparatus Sales Office, or write for bulletin GEA-6925A, Section 599-02, General Electric Company, Schenectady 5, N. Y. On applications in the natural gas industry, contact Black, Sivalls and Bryson, Inc., Kansas City, Missouri.

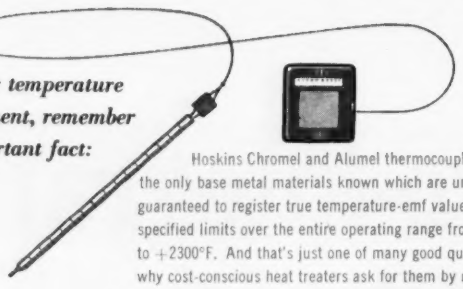
FOR QUALITY... PRODUCTIVITY ... PROFIT — INSTRUMENTATION FOR AUTOMATION

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 37 ON READER-SERVICE CARD

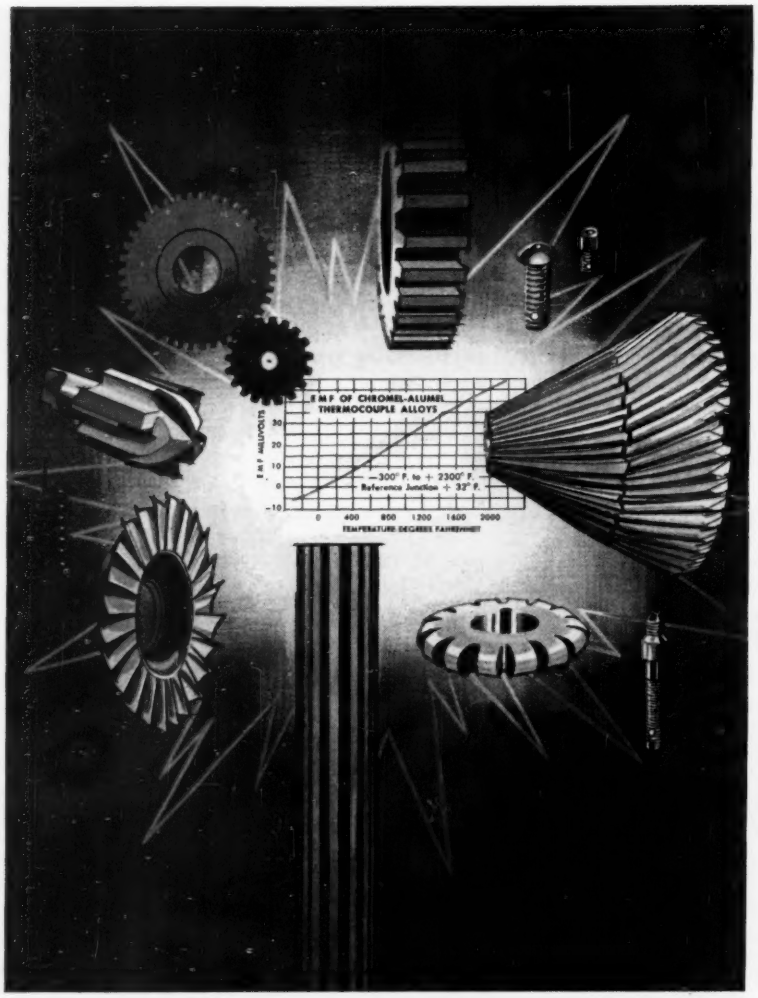
When you buy temperature control equipment, remember this very important fact:



Hoskins Chromel and Alumel thermocouple alloys are the only base metal materials known which are unconditionally guaranteed to register true temperature-emf values within close specified limits over the entire operating range from −300°F. to +2300°F. And that's just one of many good quality reasons why cost-conscious heat treaters ask for them by name . . .

Chromel®-Alumel®

THERMOCOUPLE ALLOYS



Available through instrument manufacturers, thermocouple fabricators, and pyrometer service companies. Write for complete technical data.

Trade names you can trust for accurate temperature measurement!

Genuine Chromel and Alumel are produced exclusively by

HOSKINS MANUFACTURING CO.

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Custom Quality resistance, resistor and thermo-electric alloys since 1908

CIRCLE 38 ON READER-SERVICE CARD

ICS BOOKS

Instrument Manual, edited by J. T. Miller, [c1960] United Trade Press Ltd., 9 Gough Square, Fleet Street, London, E.C.4, England, 742 pp., 11″, clothbound £5 5s. This third edition of the manual contains 26 chapters dealing with instruments measuring all conventional variables, and includes telemetering, automatic process control, and computers. A Buyers' Guide, a list of organizations in The United Kingdom interested in instrumentation, a list of manufacturers, and 100 pages of advertisements are included.

CIRCLE 199 ON READER-SERVICE CARD

Electronic Computers, by T. E. Ivall, Second Edition, [c1960] Iliffe & Sons, Ltd., Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y., 260 pp. + viii, 8½″, clothbound $15.00. This second edition of the book first published in 1956 is almost entirely rewritten to follow the rapid developments in the field. This basic concept of being a nonmathematical introduction to the principles and applications of computers has been preserved.

CIRCLE 200 ON READER-SERVICE CARD

Servomechanism Fundamentals, by Henri Lauer, Robert N. Lesnick, and Leslie E. Matson, Second Edition [c1960] McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 490 pp. + vii, 9″, clothbound $10.00. Greatly enlarged second edition presents operating features of servo-mechanisms and gives logical procedures for their design. Both transient and steady-state analysis and synthesis are covered. Differential equations are treated by classical rather than transform methods.

CIRCLE 201 ON READER-SERVICE CARD

Fundamentals of Electronics, by Mathew Mandl, [c1960] Prentice Hall, Inc., 70 Fifth Ave., New York 11, N. Y., 574 pp. + xvi, 9″, clothbound $10.60. This volume furnishes first a comprehensive detailed coverage of elementary principals to go on to such modern developments in atomic and electron theory as the subshell atom and the electron spin mechanics of magnetism.

CIRCLE 202 ON READER-SERVICE CARD

Fluid Power Control, by John F. Blackburn, Gerhard Reethof, J. Lowen Shearer, [c1960] Massachusetts Institute of Technology, The Technology Press of M.I.T. and John Wiley & Sons, Inc., 440 Fourth Ave.,

New York 16, N. Y., 710 pp. + xx, 9″, clothbound $17.50. This book consists of four major parts. Section one reviews fluid properties and fluid mechanics. Section two, the heart of the book, deals with theory and practice of hydraulic control components, with emphasis on control valves. Section three and four describe recent progress in the use of gaseous working fluids, including high-pressure pneumatics, and system analysis and design.

CIRCLE 203 ON READER-SERVICE CARD

Beam and Wave Electronics in Microwave Tubes, by Rudolf G. E. Hutter, [c1960] D. van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 378 pp. + xii, 9″, clothbound $9.75. This work analyzes the basic physical principles of microwave devices from klystrons and magnetrons to the most recent traveling-wave tubes. Using simple mathematics, microwave circuitry is developed including a full and new treatment of slow-wave guides.

CIRCLE 204 ON READER-SERVICE CARD

Ein kombiniertes Regelsystem (A combined Control System), by Ernst Pavlik and Bruno Machei, [c1960] R. Oldenbourg Verlag Gmbh, Rosenheimer Str. 145, Munich, West Germany. 204 pp., 9¼″, clothbound DM-24.00. Book describes the electropneumatic Siemens & Halske combined Teleperm-Telepneu system by thoroughly explaining first all the modules involved.

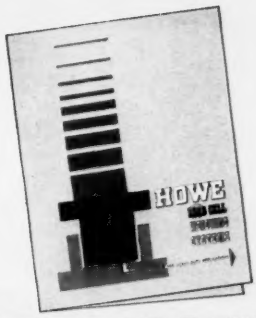
CIRCLE 205 ON READER-SERVICE CARD

Magnetic and Electrical Fundamentals, by Alexander Efron, [c1959] John F. Rider Publishers, Inc., 116 West 14th St., New York 11, N. Y., No. 2008 in the Basic Science Series, 124 pp + viii, 8½″, paperbound $2.50. Book covers magnetism, electrostatics, electromagnetism, electrical circuits and instruments. Throughout the text the Franklinian approach to current flow is used.

CIRCLE 206 ON READER-SERVICE CARD

Microwave Transmission, by J. C. Slater, [c1942], reprinted, Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 309 pp. + x, 8″, paperbound $1.50. The unabridged reprinting of the first edition, which was the first text dealing exclusively with microwaves, is still valuable for students. Deals with generators, receivers, transmission lines, wave guides, etc., using Maxwell's equations.

CIRCLE 207 ON READER-SERVICE CARD



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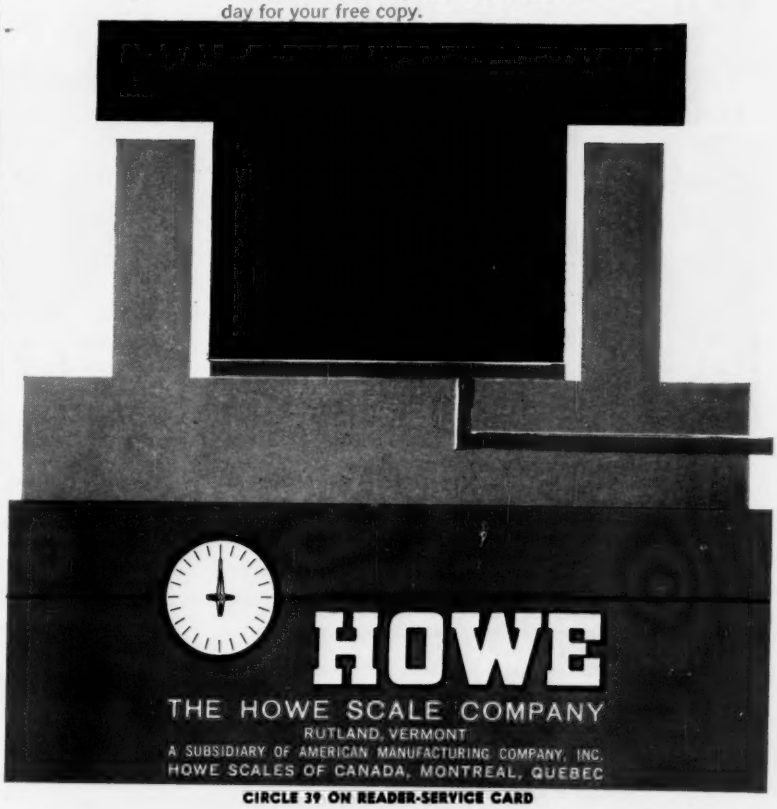
Here's complete information on the latest in load cell weighing systems for heavy duty installations—how it works, advantages, applications, components, instruments and accessories. Write today for your free copy.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A SUBSIDIARY OF AMERICAN MANUFACTURING COMPANY, INC.
HOWE SCALES OF CANADA, MONTREAL, QUEBEC

CIRCLE 39 ON READER-SERVICE CARD

Convert valves from manual to electric operation in as little as 4 hours with Valvmatic® Valve Actuator.

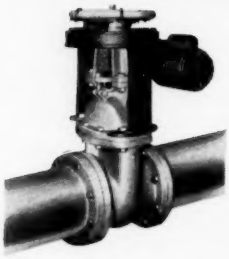
Photo by Philadelphia Inquirer

Now you can eliminate hand operation of hard-to-turn or remotely located valves with economical, easy-to-install Valvmatic.

- No special engineering or special tools
- No disturbance of piping or adjustment of valve
- No downtime of the system
- No replacing of existing valves
- No special wiring

Low initial cost. Minimum installation cost. Valvmatic converts either existing or new valves to push-button locally or remotely controlled operation. Suited also to automated or microwave applications.

High torque, instantly reversible motor, either totally enclosed or explosion-proof. Torque and position control for both directions of operation. If power fails, valve can be restored to manual operation in a few seconds. Performance tested by leading industries.



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C. H. Wheeler Manufacturing Co.

19th and Lehigh Avenue, Philadelphia 32, Pa.

WV-148

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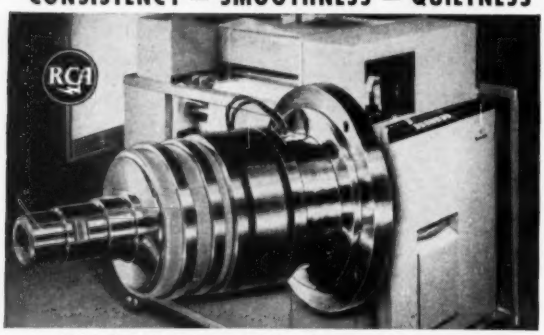
RCA Selects Simplatrol Electric Clutch Brake

CONSISTENCY — SMOOTHNESS — QUIETNESS



R.C.A. 501 Data Processing System — Electro-mechanical Printer

These are the reasons that R.C.A. engineers gave for selecting a Simplatrol CB-62 electric clutch-brake unit for use in its new electro-mechanical printer.

In this high speed application, the Simplatrol unit feeds the paper — and indexes it accurately for printing. Specially developed in cooperation with R.C.A. engineers, the Simplatrol unit gives "remarkable consistency".

In the tape drive section of the unit, the Simplatrol clutch-brake delivers a smoothness and quietness not previously available, and so necessary in business machines.

Ask for Simplatrol literature and adaptation data.

Simplatrol products corp.

24-4 SALISBURY ST., WORCESTER, MASS.

Representation in Key Industrial Areas

83-0

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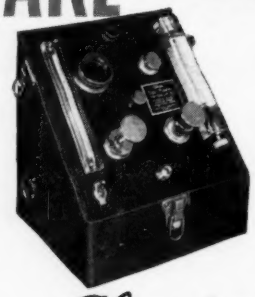
TAKE GUESSWORK OUT of DEW POINT READING with Alnor® DEWPOINTER



Anyone can quickly... accurately... read dew points with the Dewpointer. It is the only instrument that lets you see the fog in a sealed chamber under controlled conditions. Compare this fast, positive method with attempts made to tell exactly when fog forms on a mirrored surface. Completely self-contained, requires no external coolant or auxiliary apparatus ...operates on enclosed battery or AC. Available in three ranges for dew points between −20° F. and room temperature, from −80° to 0° F. and −80° F. to room temperature.

Send for Dewpointer bulletin. Tear out this ad and send on your letterhead to: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

CIRCLE 42 ON READER-SERVICE CARD

product of the pioneer

POSTERITY... *in Seconds!*

BY POLAROID AND DU MONT

Permanent TRANSPARENT records of your oscilloscope traces — for immediate projection, enlargement or study.

The unbeatable combination for fast, sharp slides of scope traces — Polaroid® Land Projection Film and a Du Mont Oscilloscope Record Camera. In two minutes, 3¼" x 4" or 2¼" x 2¼" black and white slides are ready for projection in a meeting. To record transients too fast for the eye to see — in the millimicrosecond rise time region — use the new Type 47, 3000 Speed Land Film.

Du Mont's complete line of cameras includes three models especially designed for use with 60-second Polaroid Land films. The Type 302 permits multiple exposures per picture frame for 5-inch scopes. The Type 339 does the same for 3-inch scopes, while the Type 353 enables full-size (1:1 object-to-image ratio) recordings of 5-inch scope traces for precision studies.

In less than a minute — your important scope information is recorded forever.

Write for technical details

"Polaroid"® by Polaroid Corporation

DU MONT®

precision electronics is our business

ELECTRONIC TUBES/INDUSTRIAL TV/MILITARY ELECTRONICS/MOBILE COMMUNICATIONS/SCIENTIFIC INSTRUMENTS/AUTOMOTIVE TEST EQUIPMENT

Allen B. DuMont

ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, N. J., U. S. A.

INTERNATIONAL DIVISION • 515 MADISON AVENUE, NEW YORK 22, N. Y. • CABLES: ALBEEDU, NEW YORK

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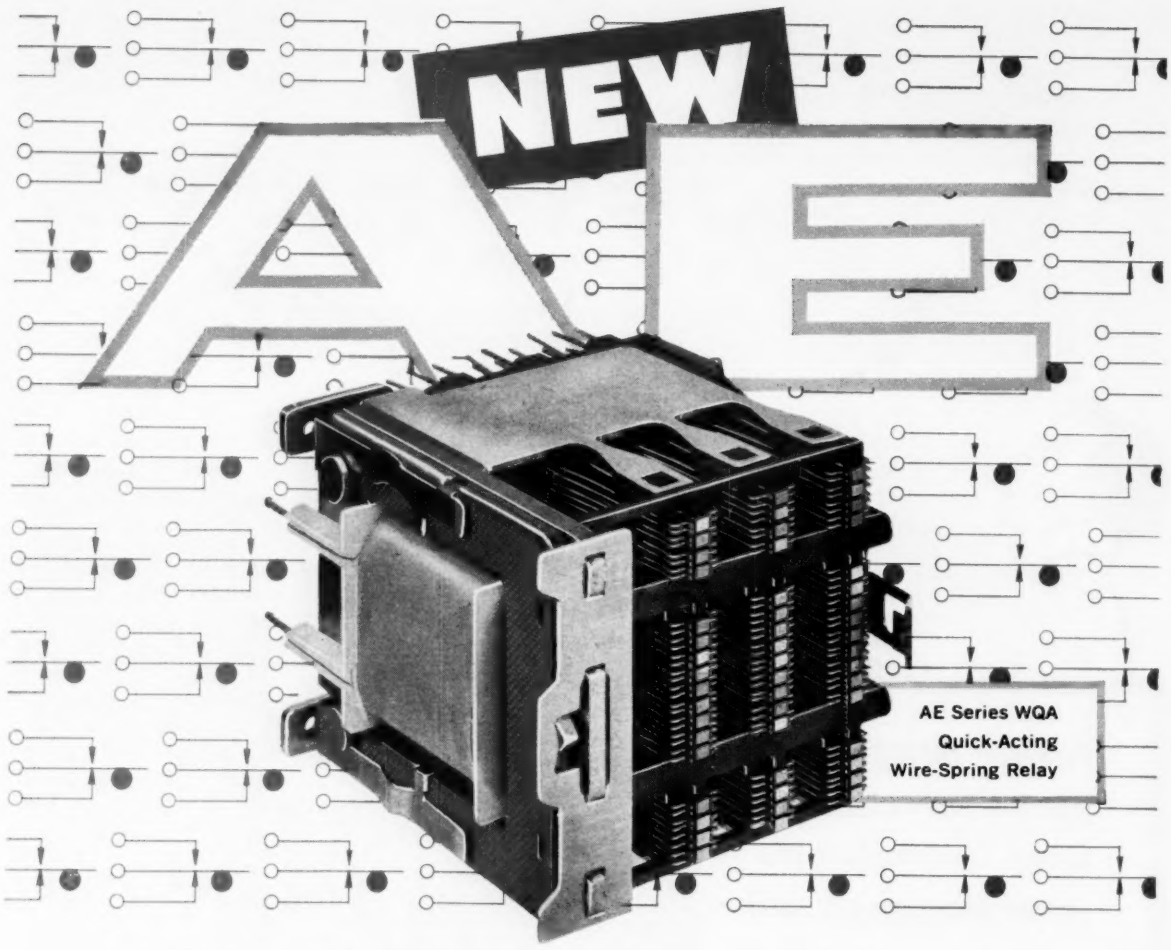

TO THE ENGINEER

who wants to transfer 51 circuits simultaneously

If you need simultaneous transfer of a large number of circuits without fail, take a look at AE's new WQA relay. It will do the work of four or more heavy-duty, general-purpose relays each with maximum spring pile-ups, and sustain 50 million or more operations without readjustment.

In the WQA relay, all moving springs pass through holes in a unique actuating "card." Moved directly by the armature, the card in turn actuates all the moving springs. This method of operation pre-establishes exact timing and sequence of all spring operations, and at the same time assures perfectly synchronized "break-before-make" on all circuits.

Contact capacities on WQA relays can be custom-tailored to your needs, with either one, two or three levels of contact assemblies available, each with a capacity of 17 Form C combinations. Other Forms available.

Our circuit engineers will be pleased to work with you in adapting the WQA to your specific design. Or, if you wish, they'll take on the complete packaging job.

If you'd like more information on the WQA relay, address your request for Circular 1957 to: Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

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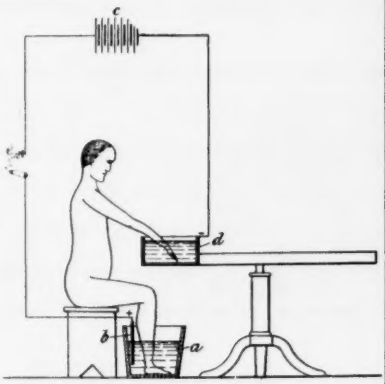
PANHANDLE PETE

Metal Extractor

This invention relates to a process for extracting metals from living bodies with the object of curing and preventing metallic poisoning.

According to this invention metals contained in a living body are removed by submitting the body to a process of electrolysis, the two poles of a source of current being connected to liquids such as water or solutions of a suitable salt, with which liquids two separate parts of the body are placed in contact. Preferably the part nearest to the part affected or likely to be affected by the metal is in contact with the liquid connected with the negative pole. For example in the case of lead poisoning the feet are placed in a bath containing water, a small quantity of common salt being preferably added and a metal plate or other electrode connected with the positive pole is put into the bath, while the hands and forearms are placed in another bath connected with the negative pole. A uni-directional and continuous current is passed through the patient, the lead being deposited in the negative bath. The electromotive force may conveniently be about 20-volts.



Thomas Maliby Clague
Patent 1,123,683
January 5, 1915

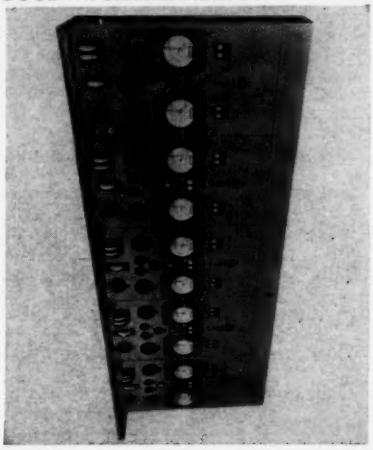
Automatic Salute

This invention relates to a novel device for automatically effecting polite salutations by the elevation and rotation of the hat on the head of the saluting party when said person bows to the person or persons saluted, the actuation of the hat being produced by mechanism therein and without the use of the hands in any manner.

To carry into effect the broad feature of this invention, which comprehends the automatic elevation and rotation of a man's hat to effect a unique salutation, I preferably employ a mechanism held in a case removably clamped on the head of the wearer of the hat, while the hat is detachably secured to the working parts of the device that raise the hat, completely rotate it, and deposit it correctly on the head of the wearer every time said person bows his head and then assumes an erect posture, all parts of the novel device being completely inclosed in and concealed by the hat.

James C. Boyle
Patent 556,248
March 10, 1896

. . . "The Company We Keep" undoubtedly all agree that: YOU DON'T HAVE TO STAND ON YOUR HEAD TO RECOGNIZE GOOD WORKMANSHIP!



If you are standing squarely on your feet and looking for a Control System manufacturing-specialist with an intimate knowledge of Industry's demands — from Power Plants to Refineries — from Steel Mills to Chemical Plants we suggest you join "the Company We Keep" and request a quotation from Electro-Mech on that planned plant automation job *you* are working on.

Electro-Mech Corp., Norwood, N. J.

Electro-Mech

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Bendix G-20

the new data processing system with the ORGANIZATION CHART *concept*

"Organization Chart" design in the Bendix G-20 means far faster, more efficient processing of scientific and business problems. The reason is clear:

The electronic manager of every data processing system is a computer. But most are poor "bosses" because they cannot delegate authority, or even supervise more than one operation at a time. Many computers run operations as complex as your own business, but with an inefficiency that you would never tolerate. Bendix engineers saw this shortcoming, and turned for a solution to the organization chart common to any well-managed business.

The G-20 Central Processor, or computer, has a staff of well-taught subordinates that can take instructions from the "boss" and go to work on their own, directing the workers that perform such tasks as reading punched paper tape and cards, looking up data on magnetic tape, and printing results. The "boss" can direct numerous subordinates, and without human intervention, schedule the work for each, making sure the most important work is done first. While the subordinates handle the details, the Central Processor is free to do the all-important computing.

This "organization chart" delegation of authority means several operations may be performed simultaneously, and with a minimum of equipment. The results? Call it "low cost per operation", or "just plain efficiency", but it is all the same . . . the Bendix G-20 gives you more performance per dollar than any other data processing system. The actual performance specifications listed at the right show the tremendous speed and power of the G-20. Components and design are the most modern in the industry today. System sizes can vary from a medium-scale system to a very large system with remote on-line or off-line sub-systems. Write for complete descriptive literature.

BENDIX AVIATION CORP., COMPUTER DIVISION Dept. J25, Los Angeles 45, California

CIRCLE 46 ON READER-SERVICE CARD

SPECIFICATIONS:

MEMORY: Core, to 32,768 words in 4096 word modules.

EXECUTE +: 7 μs. avg., fixed point, one-word precision. 13 μs. avg., floating point, one-word precision.

EXECUTE ×: 49 μs. avg., fixed point, one-word precision. 49 μs. avg., floating point, one-word precision.

ARITHMETIC: Built-in floating pt., 12 dec. digit precision.

CIRCUITRY: Solid-state; parallel; 2.5 kva.

PROGRAMMING: Symbolic assembler or algebraic compiler.

INPUT/OUTPUT: 165,000 char./second max., asynchronous.

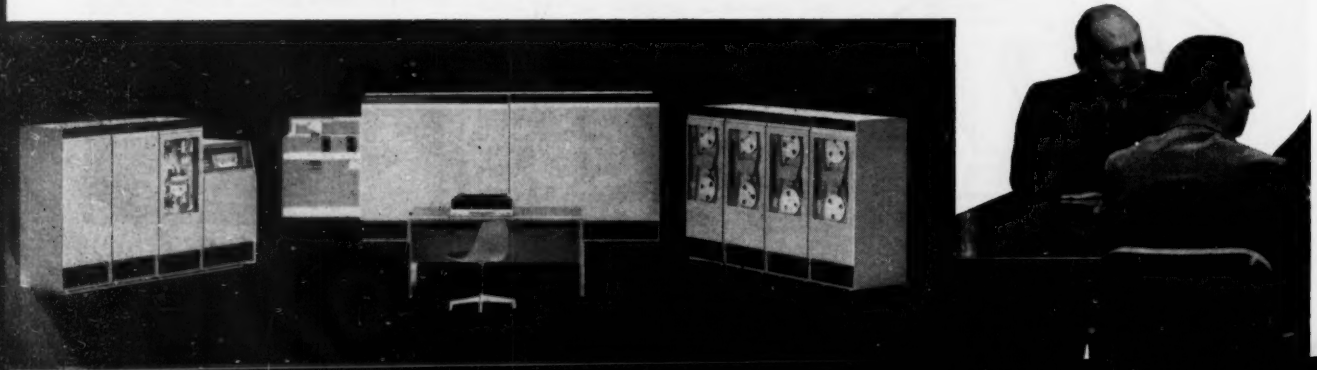
MAGNETIC TAPE: 120,000 decimal digit/second read-write.

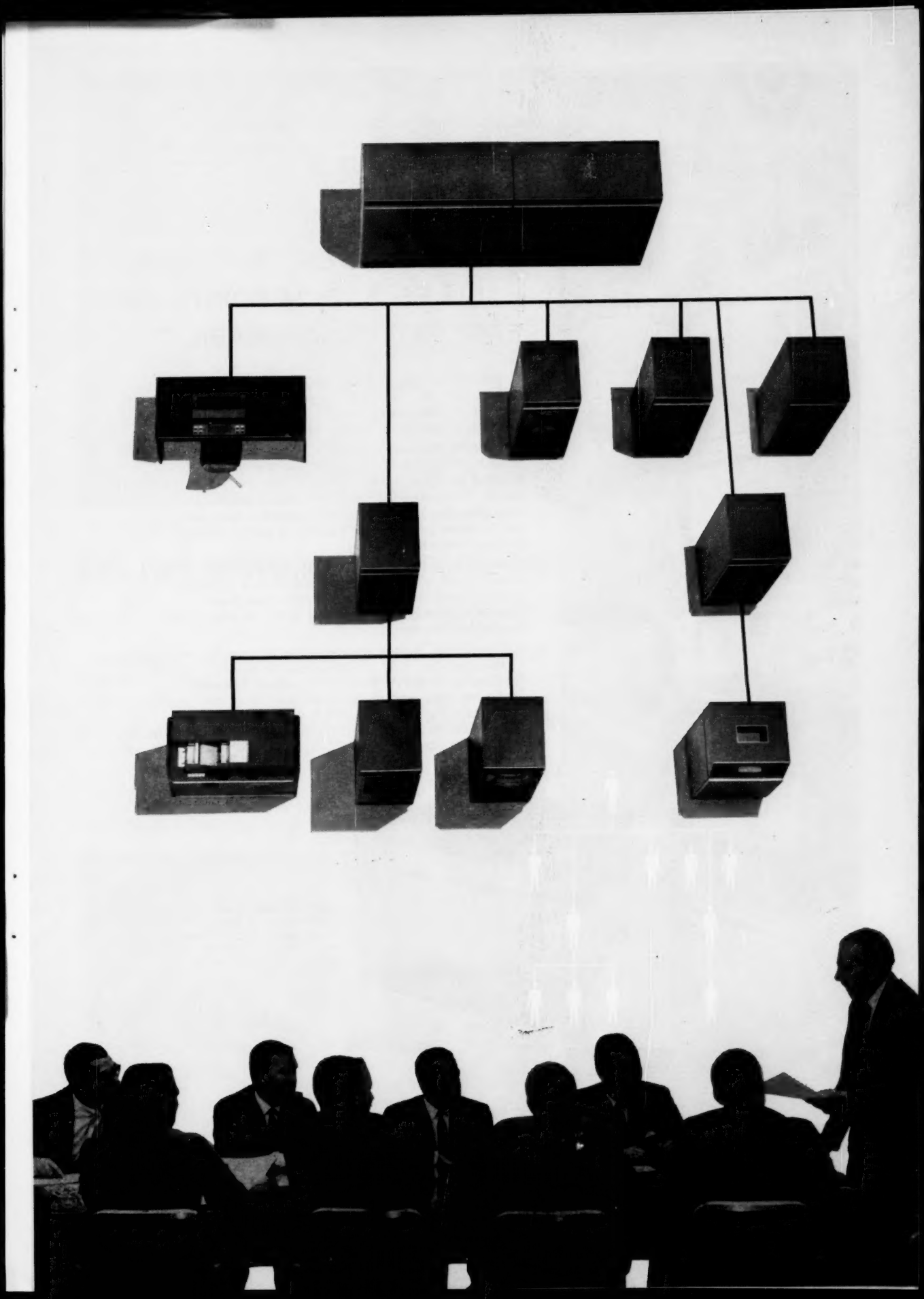
LINE PRINTERS: 600 lines per minute.

PUNCHED TAPE: 500 or more character/second readers. 100 or more character/second punches.

PUNCHED CARDS: Standard high-speed 80 column units.

CONTROL BUFFERS: 1024 character memory for data and commands. Controls transmission on-line or off-line.





DESIGNED FOR RELIABILITY THROUGH
DAYSTROM-WESTON "UNITIZED" CONSTRUCTION

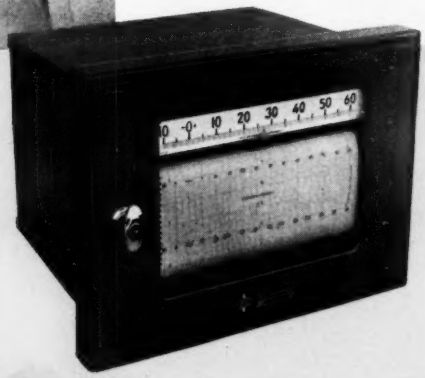
DAYSTROM-WESTON RECORDER HANDLES 2 TO 24 POINTS—WITH EASY INTERCHANGEABILITY

Proven in service by industry, the Model 6702 multi-point recorder accommodates up to 24 points in a single, compact unit. Number of points can be changed quickly. Accuracy is within ±0.25% of span or ±.025 mv on potentiometer.

Model 6702 features simplicity of design and performance. It has replaceable range standards and a plug-in amplifier. Printing and chart speeds are easily changed. Other advantages include the Weston D-PAK (T.M.) which eliminates standard cells, batteries and standardizing mechanisms . . . and a unique printed circuit switch is geared directly to the printing head.

Model 6702 is 39% smaller than the average multi-point recorder, and offers the convenience of rack mounting. It is designed and manufactured with traditional Weston craftsmanship to provide years of dependable, trouble-free service.

Ask your local Weston representative for complete information on this and other Weston instruments for industry, or write for Catalog 08-101-A. Weston Instruments Division, Daystrom, Inc., Newark 12, New Jersey.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario. Export: Daystrom's International Division, 100 Empire Street, Newark 12, New Jersey.



Model 6702 uses full-size chart. Points: 2, 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, or 24. Printing speeds: 3 to 60 seconds per point, readily changed. Operation: 115 volts, 60 cycles or 115 volts, 50 cycles.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION

CIRCLE 52 ON READER-SERVICE CARD

100% inspection of *MegopaK* thermocouples insures strict adherence to factory standards. Manufacturing area is clean, dry, air-conditioned.

Get real economy in mineral-insulated thermocouples . . . specify quality-controlled *MegopaK*

Careful quality control often spells the difference between *real* economy and just another bargain. In small-diameter, mineral-insulated thermocouples, where the art of production is as critical as the science, strict quality control is your only assurance of consistent quality and real economy.

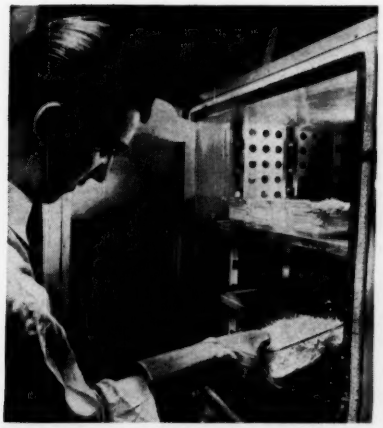
For more information on quality-controlled *MegopaK*, write for Catalog and Price List G100-4 . . . or call your nearest Honeywell field engineer.

Honeywell

First in Control

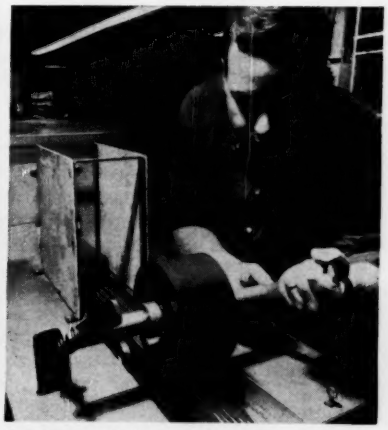
SINCE 1885

75th YEAR — PIONEERING THE FUTURE



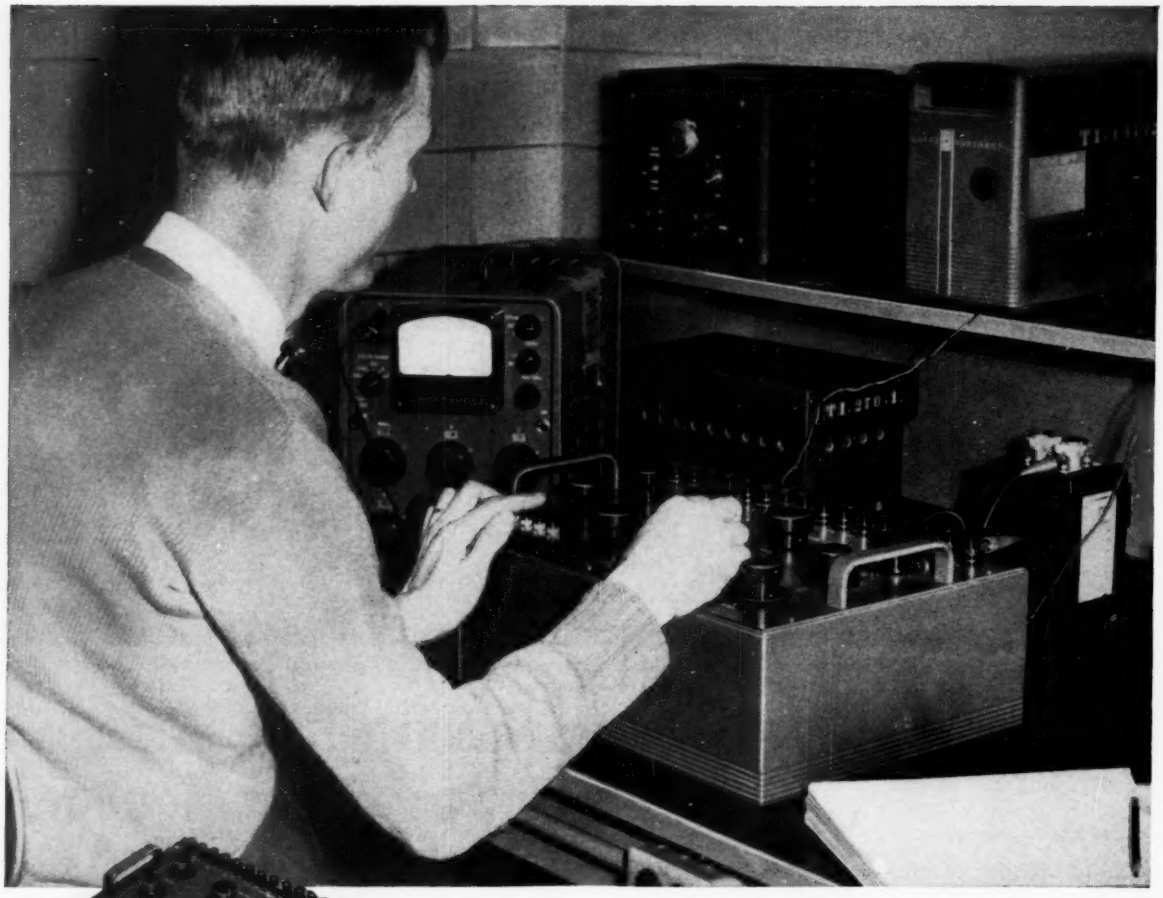
Insulators are stored in paraffin-sealed boxes, then baked to remove last trace of moisture. Assemblers wear gloves to prevent contamination of thermocouples.

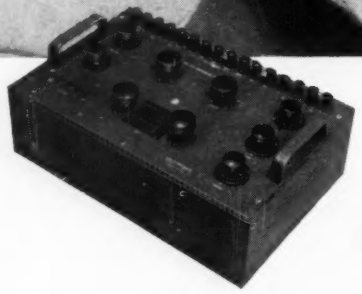
Single-pass swaging of carefully-sized wire-insulator-sheath assembly produces no distortion in wire, insures greater accuracy and longer life.



Continuous hydrogen-annealing not only produces a ductile, brightly finished product, but also identifies improperly compacted material which is rejected during inspection

CIRCLE 49 ON READER-SERVICE CARD





New Type K-3 Potentiometer keeps Melpar's radar test gear "on the beam"

Obtaining a high electrical accuracy is vital when designing and producing radar and fire control devices, analog and digital computers, etc. Melpar Inc. at Falls Church, Va., a subsidiary of Westinghouse Air Brake Co., relies on L&N's Type K-3 Universal Potentiometer as the prime d-c measuring instrument for their entire plant. The K-3 inter-compares standard cells calibrated by the National Bureau of Standards. Then, using these cells as reference, it calibrates the accuracy of voltmeters, ammeters and wattmeters used throughout the plant to check this complex electronic equipment.

This heavy workload of checking standards and instruments is easily handled by the K-3 because, as the head of the Quality Control Laboratory at Melpar says, its new design and convenience features permit "faster readings . . . and human errors are avoided because of the K-3's central reading window and decimal point indication of range. It is also much easier to standardize."

With these features, plus others such as the instrument's guarding against static and leakage, its built-in auxiliary potentiometer, etc., this Type K-3 will give you more accurate emf measurements in less time. Why not investigate the possibilities of this advanced potentiometer today. Write for the six-page Data Sheet E-51(6) on the K-3 from Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS Instruments **NORTHRUP** Automatic Controls • Furnaces

CIRCLE 50 ON READER-SERVICE CARD

Want an Overseas Instrumentation Job?

An instrument man with 25 years of overseas assignment, in four countries, lists 30 points as guides to what it takes to make a successful and happy instrument department in a foreign—or any—environment.

J. L. (Jim) LOPEZ

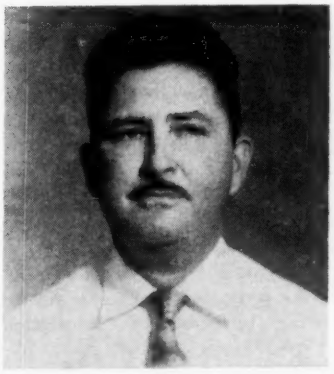
FOREIGN SERVICE has its appeal—and its disadvantages. The pay is more; but it costs more to travel home on leave. The cost of living may appear low; there may be many hidden costs associated with the living. The locale may be glamorous; but the climate may have its discomforts.

Experience is as important as education in foreign service—you may be expected to solve problems in many fields and with little help. Be prepared to do the following in the fields of (1) organization, (2) manpower development, (3) spare parts control, (4) maintenance programming, (5) associated non-instrument work, (6) community relations.

Organization

1. Organize an office along the most efficient lines. Set up an up-to-date filing system which will provide information with minimum delay.

2. Study the methods being followed in the Instrument Shop. Decide if the present shop layout can be improved. Decide what modifications should be made to the building and equipment to improve working conditions and work output. Develop shop methods, work aids, procedures and techniques along modern lines.



JIM LOPEZ IS AN EMPLOYEE OF STANDARD OIL CO. OF N. J. ON LOAN TO THE IRANIAN OIL EXPLORATION AND PRODUCING CO.

3. Establish periodic meetings with your supervisory group for the purpose of discussing current work, company policies, changes, safety, training, work problems, new instrumentation and procedures, foremanship.

Manpower Development

4. Make a personnel inventory; determine the qualifications each man has; decide what training each man needs.

5. Establish a Job Training Program which will up-grade all men; establish a schedule; set goals; set up the necessary administrative machinery to handle such a program; be prepared to evaluate the results and write reports showing that satisfactory results are being obtained.

Spare Parts Control

6. Make an inventory of Instrument and Allied equipment and establish the necessary maintenance records.

7. Draw up the necessary spare parts lists and establish a system of maintaining these parts on hand when you need them.

8. Supervise the fabrication of any spare part which may have to be made in the event of an emergency. This may call for design work, improvisation, imagination, and initiative. No job should be to complicated to perform—*the Instrument always gets fixed.*

Maintenance Programming

9. Make a comprehensive study of the major instrumentation problems of the area. Decide what control problems are the most important and what should be done first. Make a study of the process

and locate the critical points where instrumentation may or may not be causing process control difficulties. Initiate action necessary.

10. Establish a suitable system for maintaining control of the work requests so that your work force is being efficiently applied to the necessary work to be done by your section.

11. Prepare study charts of all instruments and for all business machines, which will show the equipment, the type of work to be done, the amount of time needed to service each type of equipment, and how often such work is to be done. Adapt to current work force and work conditions.

12. Prepare routine preventative maintenance programs based on study charts. Make sure all local conditions and process requirements are met.

13. Survey the area where your work is to be performed. Establish the geographical limits.

14. Develop methods as well as equipment for overhauling and repairing *electrical measuring* instruments.

15. Develop methods as well as equipment for repairing all types of *electronic equipment* such as amplifiers, radios, projectors, tape recorders, instruments, etc.

16. Study the calibration methods being used for checking pressure gages, flowmeter, temperature instruments, scales, clocks, etc.

17. Establish comprehensive Orifice Computation Files. Streamline this job to make it simple enough for the clerk to handle.

18. Make studies of special types of equipment which come under your supervision—chlorinators for example.

19. Develop new methods which will be applied in the field such as alterations necessary to existing meter piping to bring it more in line with modern practice. Can better sealing methods be used? Is it a good practice to carry a Dead-Weight tester around in a truck to check gages in the field?

Associated Non-Instrument Work

20. Make an inventory of all business machines and establish the necessary maintenance records.

21. Develop and train men to work on a metal lathe, drill press, and other machines.

22. Develop methods as well as equipment for repairing watches, clocks, and other time measuring devices and fine work.

23. Train personnel to overhaul and repair all types of hospital equipment such as X-ray machines, sterilizers, incubators, surgical apparatus.

24. Install a spray-painting system.

25. Develop means of doing your own oxy-acetylene welding on small brazing jobs to cut down delays caused by having this done elsewhere.

26. Make transportation studies to present your arguments for better transportation facilities.

27. Maintain close communication with all groups that can affect your job.

28. Make sure your work is understood by all others.

29. Contribute something useful and worthwhile to the community where you are going. This is not a necessity, but it makes your stay more pleasant and gives you a sense of participating and belonging.

30. Be tolerant; respect the religions and customs of others; be helpful; try to understand the people where you are stationed; make a special effort to learn the language of the country; accept conditions as they are and avoid comparing them (out loud) with conditions at home; be friendly. Above all don't forget that you are American and are proud of it!

Creative Thinking

DICKEY DYER
Pinceton, N. J.

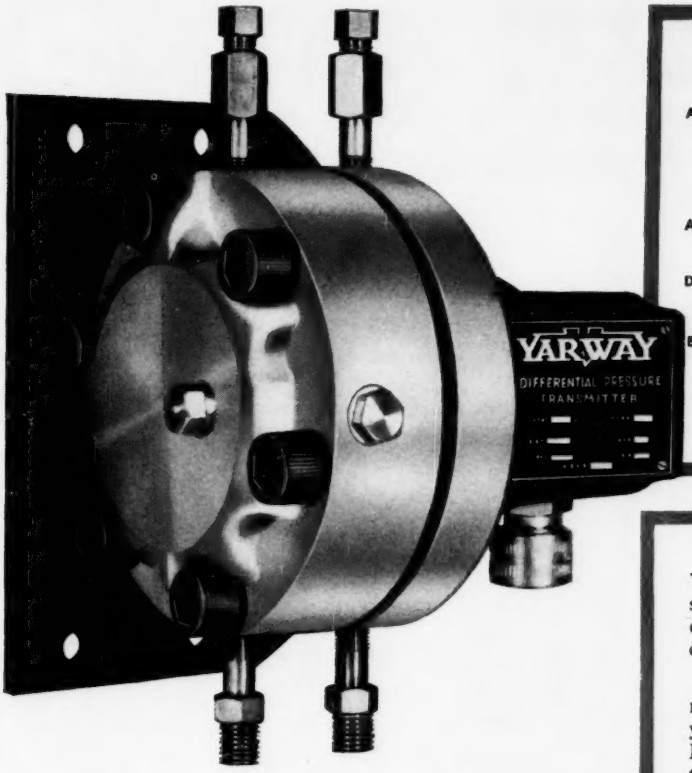
TOP management does three things—they run the business, they run the key people, and they run the hourly help and what the hourly help does. All top management action is as least three-fold in effect, bearing on the business itself, the key people, and the hourly help, but since all top management action also bears on the present and on the future, its effect is actually at least six-fold. Top management must seek to avoid jeopardizing the future strength of the business in the interest of high returns today; else there may be no continuing business. Top management must seek to avoid jeopardizing the present strength of the business in the interest of high returns tomorrow; else there may be no continuing business.

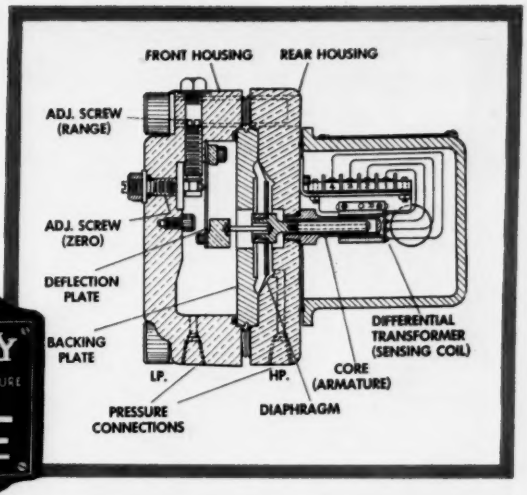
Then how can "automation" contribute to the decisions and the actions of top management?

To the extent that top management can secure more facts more quickly about how things are working out, to that extent can they take corrective action more assuredly, more quickly, both as to time chronology and time consumption. Thereby can they lessen their preoccupation with the affairs of the present and focus their attention on the possibilities for the future.

Since automation permits a more versatile, more flexible and more vital business enterprise, the traditional methods for justifying the purchase of equipment based on what the equipment will save are inadequate in evaluating purchase of automation equipment.

Abstracts from talk presented at 4th Int'l Automation Exposition, New York, N. Y.





Yarway offers maximum simplicity in new DIFFERENTIAL PRESSURE TRANSMITTER

for fluid flow and liquid level measurement and control in power and process plants, including nuclear applications

YARWAY now offers a unique Differential Pressure Transmitter to operate remote indicators, controllers or other electrically-activated receiving instruments.

It uses the same simple diaphragm mechanism which has proved so successful for 20 years in the YARWAY Remote Liquid Level Indicator. The diaphragm moves in response to changes in differential pressure and produces proportional changes in the electrical output of a sensing coil or differential transformer.

CHECK THESE ADVANTAGES

- Accurate and sensitive.
- Range adjustable from 0-6″ H_2O minimum to 0-400″ H_2O maximum.
- External range and zero adjustment.
- Operating pressures up to 3000 psig.
- Full over-range protection.
- Small displacement—rapid response.
- Compact—approx. 8″ x 8″ x 6½″.
- Light weight—approx. 27 lbs.
- Easily installed.
- Completely dependable and proven diaphragm mechanism.

For full description, specifications, drawings, etc., write

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YARWAY

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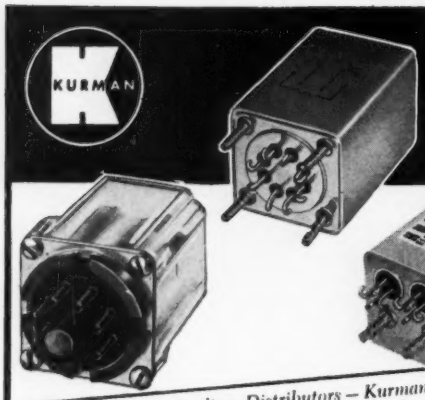

would **IMMEDIATE DELIVERY** of stock relays at factory prices save you engineering or purchasing time...?

. . . if the answer is **"YES"** *call a* **KURMAN SALES AGENCY** *today!*

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Schenectady Electronic Dist. Corp., Schenectady
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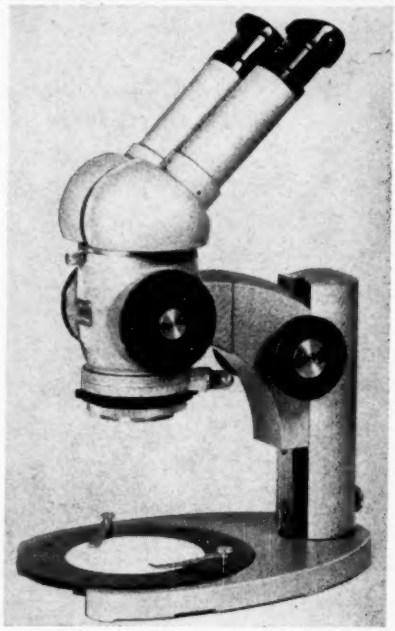

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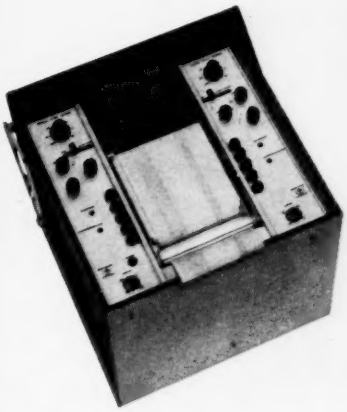

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For recording *two variables* simultaneously, the Model 320 provides a versatile, transistorized amplifier for each input signal. The rugged 2-channel recorder assembly has heated stylus recording on two *50 mm wide* rectangular coordinate channels, 4 pushbutton chart speeds, and 6 inches of visible chart. The Recorder can be placed vertically, horizontally or at a 20° angle.

MODEL 320 SPECIFICATIONS

Sensitivity: 0.5, 1, 2, 5, 10, 20 mv/mm and v/cm
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Common Mode Rejection: 140 db min. DC
Calibration: 10 mv internal ±1%
Output Connectors for each channel accept external monitoring 'scope or meter
Price: $1495

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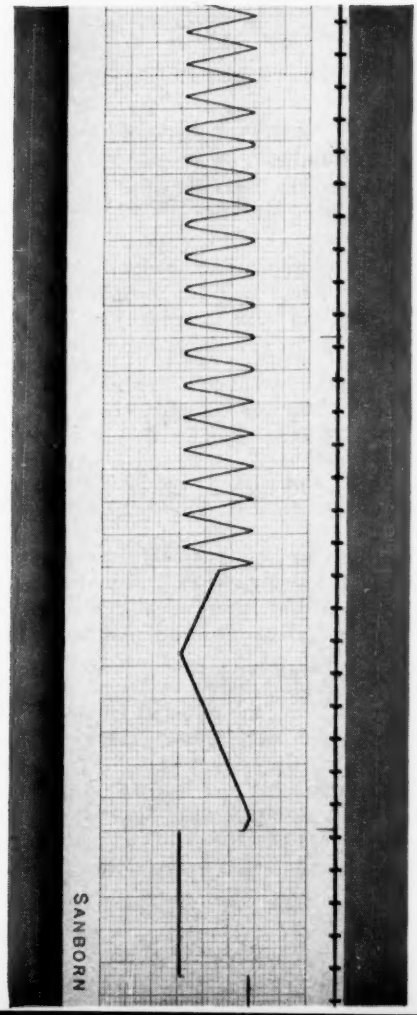

single channel

Two models of this 21 lb. brief case size recorder are available — Model 301 for AC strain gage recording, Model 299 for general purpose DC recording. Both provide immediately visible, inkless traces by heated stylus on 40 division rectangular coordinate charts . . . frequency response to 100 cps . . . 5 and 50 mm/sec chart speeds . . . approx. 4 inches of record visible in top panel window.

MODEL 301 SPECIFICATIONS

The amplifier section of the Model 301 is an all-transistorized carrier type with phase sensitive demodulator. The power supply and internal oscillator circuits are also transistorized.
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Attenuator Ratios: 2, 5, 10, 20, 50, 100, 200
Carrier Frequency: 2400 cps internal
Transducer Impedance: 100 ohms min.
Calibration: 40 uv/volt of excitation
Output Connector: for external monitoring 'scope or meter
Price: $750

MODEL 299 SPECIFICATIONS

Combines the dependability of transistors with the high input impedance of vacuum tubes for reliable broad-band DC recording.
Sensitivity: 10, 20, 50, 100, 200, 500 mv/div and 1, 2, 5 and 10 v/div
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Common Mode Voltage: ±2.5 volts max. at 10 mv/div sensitivity increasing to ±500 volts max. at other sensitivities
Common Mode Rejection: 50:1 most sensitive range
Calibration: 0.2 volt internal ±1%
Output Connector: for external monitoring 'scope or meter
Price: Model 299 (with zero suppression) $700
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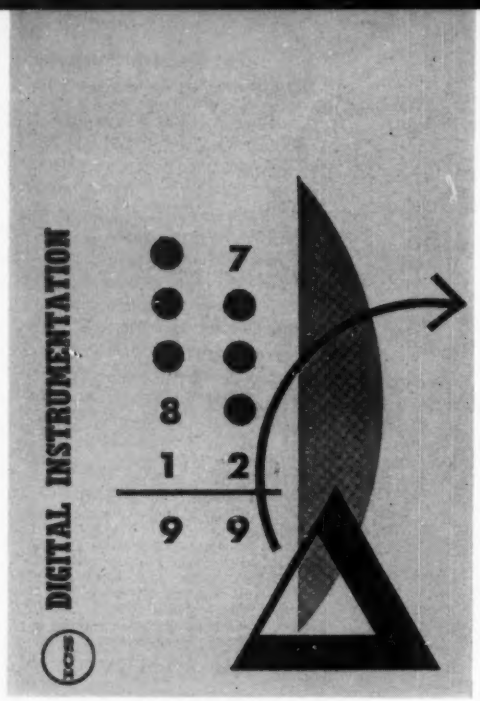

Serial Comparison by Symbolic Logic

ROBERT BROOKS
Computer Control Co., Inc.

Serial comparison is the comparison of two multibit numbers, bit by bit, starting with the least-significant bit. Comparison for equality and inequality can be made using logic charts and gating packages.

SERIAL EQUALITY COMPARATORS are devices used to compare two serial binary (*multibit*) numbers, A and B, and ascertain whether A and B are equal.

If a disagreement is encountered during a comparison (say, the second bit in each number differs), the circuit must be disabled and remain that way even if later bits of the number agree. For example, if 101 is being compared with 111, the first bits will agree but the second will disagree. *Any disagreement* must disable the circuit permanently. To do this the variable E is introduced and is defined such that E equals 1 so long as A equals B, but that E becomes 0 at any time that A and B are found to be not equal, and remains 0 thereafter. The variable E is the output of the serial comparator, and is used also in stating the conditions necessary for the output, as shown in Fig. 1.

The logic chart for serial equality comparison is shown in Fig. 1. The logic chart says that an output occurs when A and B are equal *and* pulse E exists. Squares 2 and 6 establish this, and two gates are required.

The implementation is shown in Fig. 2. A third gate is used to establish the initial E via an initial reset pulse R. As soon as R appears, E appears. As E is set equal to 1 at the beginning of the comparison, and if the digits of A and B agree, E remains equal to 1. Should a disagreement between A and B appear, E becomes false (E = 0) and, although future sets of A and B digits agree, the false E

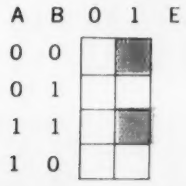

FIG. 1. LOGIC CHART for comparing the equality of A and B. The E pulse is used to disable the circuit permanently whenever A and B are not equal—that is, E must exist to have an output.

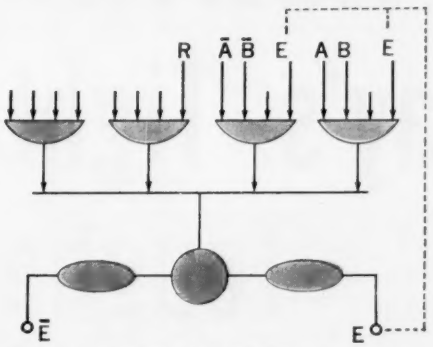

FIG. 2. IMPLEMENTATION of the logic chart of Fig. 1 using a commercial gating element. Oval unit is a delay line so output can be used in succeeding comparisons.

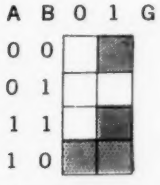

FIG. 3. LOGIC CHART for "A greater than B" comparison. The G pulse is used as a memory pulse to remember that A is greater than B thus far in the comparison.

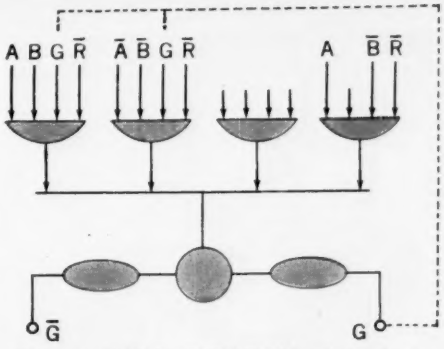

FIG. 4. IMPLEMENTATION of the logic chart of Fig. 3.

prevents the indication of a successful comparison. On the other hand, if A and B agree throughout, then E will remain true all the time and an output pulse will exist at the conclusion of the comparison.

Serial Inequality Comparator

Let us establish the logic for ascertaining if A is greater than B, where A and B are multibit numbers. The following example shows the three basic rules of logic for deciding if A > B. The least-significant bits are compared first

Comparison	4	3	2	1
A	0	1	1	1
B	1	1	0	1
Output G	0	1	1	0

Rule 1: When bits are equal (whether 1 or 0) output does not change, as shown by comparisons 1 and 3 above.

Rule 2: When an A bit is greater than a B bit, the output signal is to appear, as shown by comparison 2 above.

Rule 3: When a B bit is greater than an A bit, output signal becomes zero, as shown by comparison 4 above.

To implement these rules of logic, it is necessary to introduce a memory or hold pulse (G) which establishes the fact that the disagreement (A > B) has occurred, and to use this pulse in succeeding comparisons. This is done by a simple feedback loop and delay line, as shown by the right-hand gate in Fig. 4, which produces a G pulse whenever A is greater than B, and permits it to be used in succeeding comparisons because of the delay oval shown.

The logic chart in Fig. 3 shows that an output occurs if A is greater than B, regardless of whether G exists or not. This is shown by squares 7 and 8.

G is used as a memory pulse for the next comparison (because of the delay line shown in Fig. 4).

Squares 2 and 6 in the chart establish the fact that if G exists (which means that A *has been* greater than B), then the output remains on as long as A and B are equal, according to rule 1.

The implementation of the complete logic chart is shown in Fig. 4.

The reset pulse R disables the entire circuit and returns it to zero.

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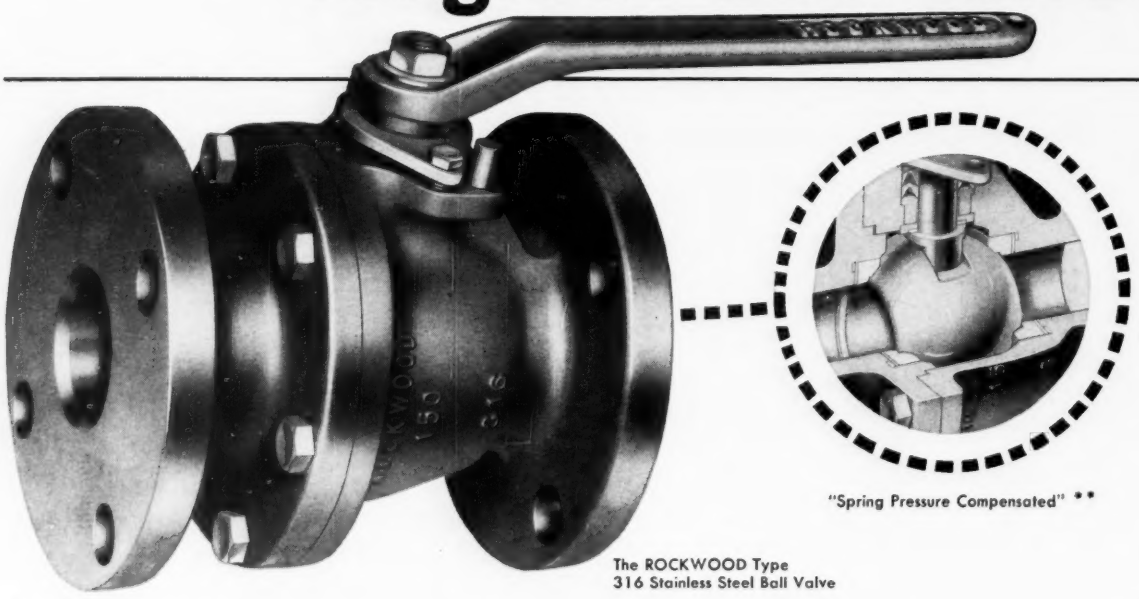

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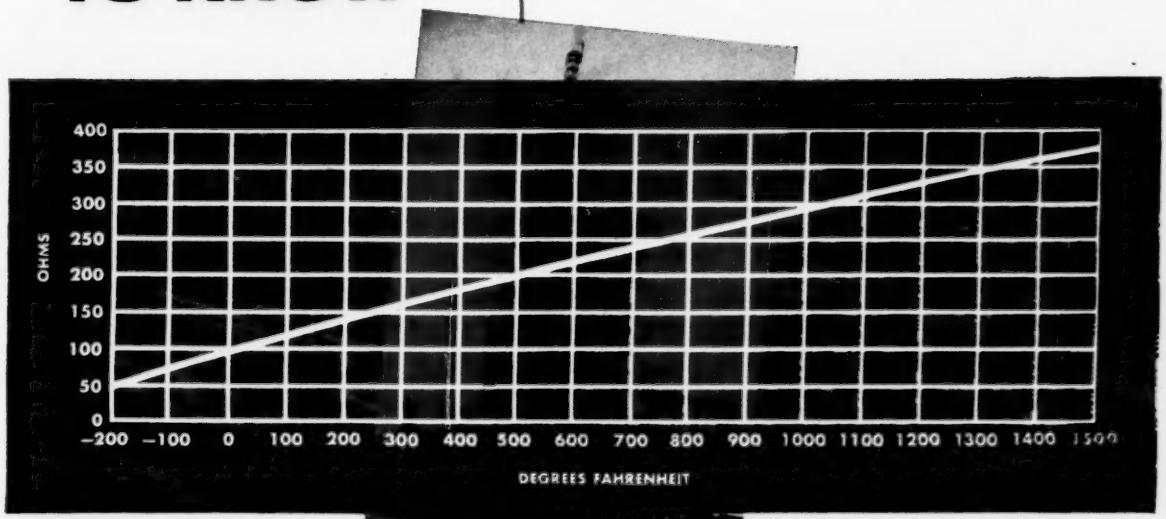
WHEN IT IS VITAL* TO KNOW



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New manufacturing methods and new materials now enable Edison to offer a wide variety of Resistance Temperature Detectors for virtually any industrial temperature measurement. Edison RTDs indicate, record or control temperatures precisely and quickly, over a long period of years – without drifting, without maintenance and without errors due to ambient temperatures, stray elecrical fields, nuclear radiation, shock or vibration.

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Standard detectors are available for use in the bearings of all types of machinery, to measure temperatures under nuclear radiation, on air compressors or in any chemical or petrochemical process. A wide variety of detectors for special purposes and for measurements to 1,800°F is also available from Edison, leader in the field.

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See page 790 for our technical article on *Resistance Temperature Detectors*.

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TEMPERATURE STANDARDS

The National Bureau of Standards is extending its temperature standardization program toward the extremes of the temperature scale. Here is a survey of NBS activities in temperature standardization and calibration.

R. E. WILSON
National Bureau of Standards

A FUNDAMENTAL basis for precise temperature measurements is provided by the International Temperature Scale, established in 1927, over the range from the boiling point of oxygen to the highest temperatures of incandescent bodies and flames. It is based on six reproducible equilibrium temperatures, or "fixed points":

1. Boiling point of oxygen: −182.97°C
2. Freezing point of water: 0.000°C
3. Boiling point of water: +100.000°C
4. Boiling point of sulfur: +444.60°C
5. Melting point of silver: +960.5°C

The measurement of temperature from −190° to +660° C is based on the indications of a standard platinum resistance thermometer used in accordance with specified formulas. From +660° to the gold point, the platinum/platinum-10% rhodium thermocouple is standard; above 1063°C, the optical pyrometer is used.

The same fixed points, with one slight modification, are specified in the 1948 scale. Only two revisions in the definition of the scale resulted in appreciable changes in the numerical values assigned to measured temperatures. One of these was the change in the value for the silver point from 960.5° to 960.8°C, which made numerical values of temperatures measured with the standard thermocouple in the range between 630° and 1,063°C somewhat higher, the maximum difference being about 0.4 degree near 800°C. The other change was the adoption of a new value for a constant in the radiation formula used to calculate temperatures above the gold point as observed with an optical pyrometer. Also, in the new scale, Planck's radiation formula is specified instead of Wien's for calculating these temperatures.

FIG. 1. CLINICAL THERMOMETERS are heated by immersion in a stirred water bath the temperature of which is determined by reading a previously calibrated liquid-in-glass thermometer with the aid of a telescope.

Temperatures Below The Oxygen Point

The International Temperature Scale is commonly used from its lowest limit (the normal boiling point of oxygen, −182.97°C or 90.19°K) to the highest temperatures measured. For temperatures below the oxygen point (down to about 10°K) the Bureau maintains an auxiliary scale based on the resistance of capsule-type platinum resistance thermometers, some of which were calibrated using a helium gas thermometer.

High Temperatures

A significant advance in the measurement of extremely high temperatures was the recent development of an *iridium/iridium-rhodium thermocouple*. Because of the high temperatures—up to about 3800°F—which prevail in the primary burning zones of turbojet and ramjet combustion chambers, conventional temperature-sensing instruments are not suitable. In preliminary studies, the new thermocouple has been found to withstand both the thermal and mechanical stresses incident to combustion-chamber operation, and heat-resistant supporting tubes and insulators are now being developed so that the devices can be used in flight.

A search is now under way for a better material to substitute for the alumel wire of a chromel-alumel thermocouple. When used under conditions encountered in exhaust gases in aircraft engines, the alumel becomes brittle and fails after a relatively short period of operation. Available substitutes for alumel which appear likely to withstand the vibration and corrosive atmosphere are being investigated to determine their performance under these extreme conditions.

Calibration Service

The Bureau calibrates the three standard instruments (platinum resistance thermometers, platinum/platinum-rhodium thermocouples, and optical pyrometers) and certifies them for other laboratories throughout the Nation.

Other thermocouples, as well as liquid-in-glass thermometers and ribbon-filament lamps, also are certified by NBS.

Standard resistance thermometers and thermocouples are used to determine the temperature of the testing baths and furnaces. Some types of liquid-in-glass thermometers are also calibrated against standard resistance thermometers and then are used as working standards to calibrate other liquid-in-glass thermometers. Approximately 2500 temperature-measuring instruments—optical pyrometers, ribbon-filament lamps, resistance thermometers, thermocouples, and liquid-in-glass thermometers—are certified each year for Federal agencies, State and municipal governments, industrial laboratories, and manufacturers. About 48,000 clinical thermometers, a sampling of a much larger number, are also tested each year for the Veteran's Administration, the U. S. Public Health Service, and the U. S. Department of Agriculture to insure compliance with specifications (Fig. 1.)

Calibration of Standard Instruments

Calibration of a *standard platinum resistance thermometer* throughout its range is carried out by

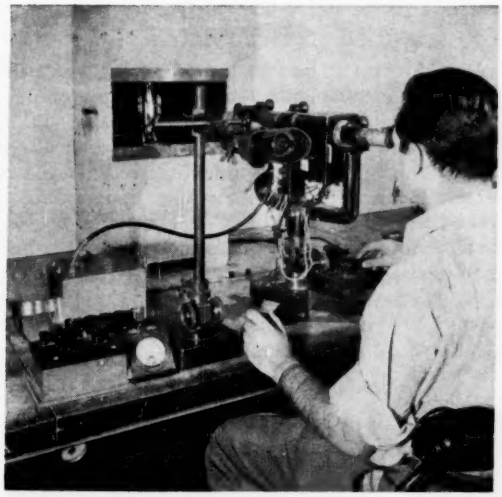


FIG. 2. NBS CALIBRATES an optical pyrometer by comparison with a standard pyrometer (right). Both instruments are sighted on a ribbon filament lamp.

FIG. 3. HIGH-TEMPERATURE calibration of a thermocouple. An optical pyrometer is being used to determine the temperature of the tc hot junction in a crucible with in an r-f-heated coil.

measuring the resistance of the thermometer at the oxygen point, the ice point, the steam point, and the sulfur point. From these data, constants are calculated for the interpolation equation which gives the resistance of the thermometer at any given temperature in terms of that temperature and the resistance of 0°C.

The *standard thermocouple,* which must contain platinum of high purity and must satisfy certain specific requirements concerning the electromotive force it develops, is calibrated by measuring its emf when one junction is maintained successively at a temperature between 630.3°C and 630.7°C (as determined by a standard resistance thermometer), at the silver point, and at the gold point. The reference junction of the thermocouple is held at 0°C. These three values of emf permit the calculation of the three constants in a quadratic equation which relates electromotive force to the corresponding temperature.

Optical pyrometers measure the temperature of incandescent bodies by visual comparison of a portion of the radiation from the hot body with that emanating from an incandescent lamp filament (Fig. 3). Calibration of such an instrument involves a determination of the pyrometer lamp current which corresponds to a stated temperature. This is done by comparison of the pyrometer under study with a previously calibrated standard pyrometer, both instruments being sighted upon a ribbon-filament lamp which serves as a source of constant temperature (Fig. 2).

The current-temperature relation for the standard pyrometer is determined by means of Planck's law of radiation. In this process the pyrometer lamp current corresponding to the gold point (1,063°C) is first determined by matching the brightness of a portion of the lamp filament with that of a black body immersed in freezing gold.

The calibration is extended above the gold point by using a ribbon-filament lamp and sector disks. The temperature of the ribbon-filament lamp is first adjusted until its brightness, when viewed through a given rotating sector disk, is equal to that of a black body at the gold point. From the known fractional transmission of the sector disk, the brightness temperature of the lamp itself, without the disk, is calculated by means of Plank's law. The sector disk is then removed, and the pyrometer lamp current is increased to obtain a brightness match between the pyrometer lamp and the ribbon-filament lamp. When this match is obtained, the pyrometer current corresponds to the calculated temperature.

In order to be able to calibrate commercial pyrometers below the gold point, the calibration of the standard pyrometer is extended to lower temperatures by inserting, in turn, various rotating disks between the pyrometer and the gold-point black body and observing the pyrometer lamp current required to match the resulting reduced brightness. The corresponding temperatures below the gold point then are calculated from the fractional transmissions of the various sectors and Plank's law of radiation. By use of sector disks with different angular openings, the pyrometer lamp currents for various temperature on either side of the gold point are determined, and a complete calibration is obtained by interpolation.

The Ice Point

The most commonly used fixed point in thermometry is the ice point, which is defined as the temperature of equilibrium at a pressure of one atmosphere between ice and air-saturated water. In practice, this definition is difficult to realize exactly because all impurities except air (the composition of which is not specified) must be absent and because complete saturation by air is difficult to attain. Fortunately, the effects of these factors are small except in measurements demanding the highest precision.

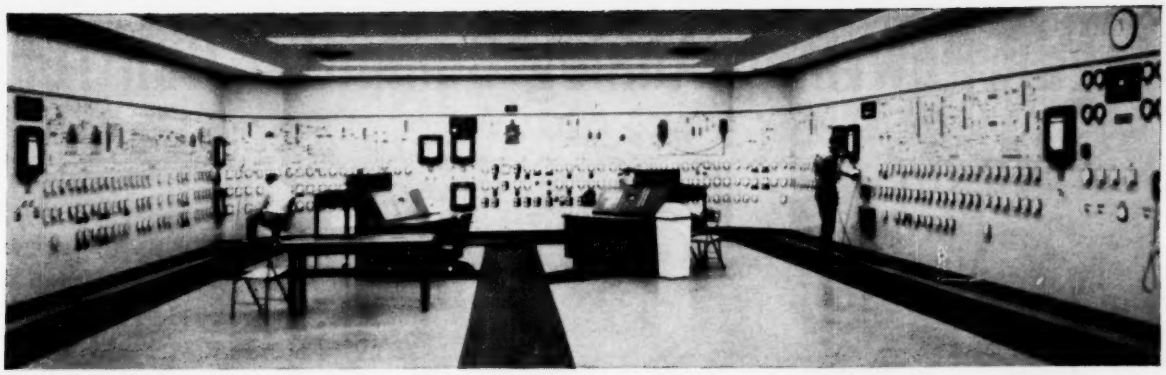
When the ice point was first defined, the ice bath, made of finely divided pure ice and distilled water exposed to the atmosphere, was assumed to be sufficiently accurate to fix the ice-point temperature within 0.001°C. Later, however, when an accuracy of 0.0001°C was desired, a more reproducible standard became necessary. The Bureau therefore began investigation of the triple point of water, defined as the temperature at which ice, liquid water, and water vapor are in equilibrium. As a result of this work, a special apparatus known as a *triple-point cell* was designed for determination of the triple point, and the triple point is now used by the Bureau instead of the ice point for high-precision measurements.

Experiments carried out in 1942 showed that the triple point is very close to 0.0100°C (0.00997°C) and that its value as obtained with the triple-point cell is reproducible to within approximately 0.0001°C.

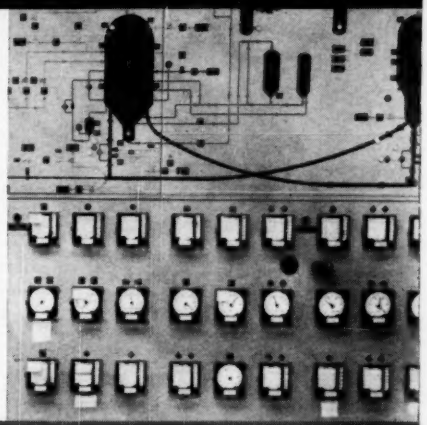
Steam Point

Next in importance to the ice point (or triple point) is the steam point, defined as the temperature of equilibrium between liquid water and its vapor under the standard pressure of one atmosphere. The Bureau has conducted considerable research in an effort to make this temperature as reproducible as possible. A controlled-pressure system employing a precision manometer has been used for the calibration of standard platinum resistance thermometers. With this equipment a change in pressure equivalent to 0.00001°C at the steam point can be detected, and determinations of the steam point made during one day agree within 0.0001°C.

As a result of NBS research, the use of pressure control has now been extended to measurements of the sulfur point. The new method uses a closed aluminum boiler having wells for 10 thermometers and connected to the precision manometer. This apparatus will make possible a study of the sulfur point as a precise fixed point for thermometry.



Bristol Metagraphic recorders and indicators occupy lower three rows on panel (shown in two photos above). Enlarged panel section is shown below, right.



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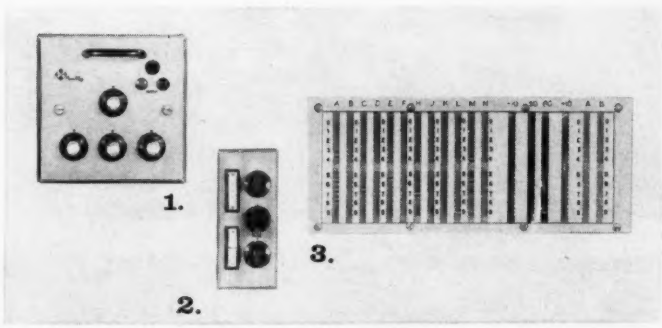


PowrMag systems embody the highest degree of flexibility. Simple, efficient electrical design utilizing long-lived and trouble-free solid state components, and rugged mechanical construction suit the system for a variety of industrial process control applications.

1. *Magnetic Control Unit*

This magnetic amplifier, operating on 1-9v DC, may be used individually, as a single 2 or 3 mode controller, or as one element in a large system. Each control unit may be removed from the front of the panel for easy interchangeability. The basic unit is easily converted to other modes by the addition of interchangeable, plug-in circuits for *all* common control operations. Inventory is reduced to the one basic unit. Unaffected by shock or vibration, PowrMag has no moisture, dirt, leakage or freezeup problems—3.5 watts of unregulated 110v, 60 cycle AC. Size—5¼" x 5¼".

2. *Remote Control Station*

These stations provide for remotely established set points and required manual control operations. Full station may contain two single or ganged potentiometers, one switch and two meters. Size—2¼" x 5¼". Half stations available with set point, bias or ratio dial and output signal indicator. Size—2¼" x 3⅛". Each station uses 12-wire, color-coded electric cable with MS-type connector. Front mounting and removal make it ideal for the compact console installations required for centralized control.

3. *Patchboard*

Interconnecting the system in any desired manner, via color-coded electrical cable, the patchboard requires no solder connections or terminal boards—all connections are made by special taper pins. Each connection is identified by an alphanumeric combination. Numbers, run vertically, identify the components in the system, such as magnetic amplifiers, controllers, transducers, etc. Letters, run horizontally, identify the connectors leading into the patchboard. DC control power bus is in the center section—no AC voltages are used in the patchboard.

Easy front access permits simple changing of operations. Additional loops or components are readily added to the system.

A letter or phone call will bring you complete information on the PowrMag system. **Ask for Bulletin MSP-163.**

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PENNSYLVANIA

HAGAN DIVISIONS: CALGON CO. — HALL LABORATORIES — BRUNER CORP.

CIRCLE 51 ON READER-SERVICE CARD

Temperature Standards

By taking a physical constant—the triple-point temperature of water—to define the temperature scale, we have gained a great deal.

A. G. McNISH
National Bureau of Standards

THE DESIRE of metrologists to have their units of measurement embodied in indestructible, immutable standards was evidenced by the founders of the metric system. There are good practical reasons for this desire. If realized, we would be assured that measurements made at one time would be strictly comparable with those made at another, unless the substances and the laws of physics are themselves changing with time. But most important is the circumstance that each adequately equipped laboratory could have its own set of standards known to be identical with those of a similar laboratory without the need for regular intercomparisons.

In the early days of the metric system, it was necessary to abandon this desire in order to achieve the greatest precision in measurements. To what extent are we now able to substitute physical constants for the artificial standards of our measuring system without imparing accuracy? We should like, of course, to adopt physical constants of the most basic nature to set the scale of our measuring system (such as G, h, c, and k), but precise measurements cannot be made in terms of them. Improvement can be obtained by abandoning G and using another constant instead of it, but the improvement is not enough.

We can gain considerable improvement in precision, though with a sacrifice of elegance, by selecting less general physical constants as the standards for our measuring system. In fact, this already has been done for one physical quantity, temperature, since the number 273.16 is assigned to the triple-point temperature of water on the thermodynamic Kelvin scale. We can see what an advantage this is, because anyone versed in the art of temperature measurements can construct his own triple-point cell and establish a standard of temperature which can be realized with a precision of two or three ten-thousandths of a degree. Furthermore, this standard can be reproduced at any time in the future with complete confidence that the standard will be the same. (The definition is still deficient in that the isotopic composition of the water is not specified, but this fault will probably be corrected in the future.) Pleasing to think about, although of no immediate advantage, is that a man on Mars, or even in some other solar system or galaxy, could establish the same standard for temperature measurements as we use on the earth.

TABLE 1—ACCURACY AND PRECISION OF TEMPERATURE MEASUREMENT

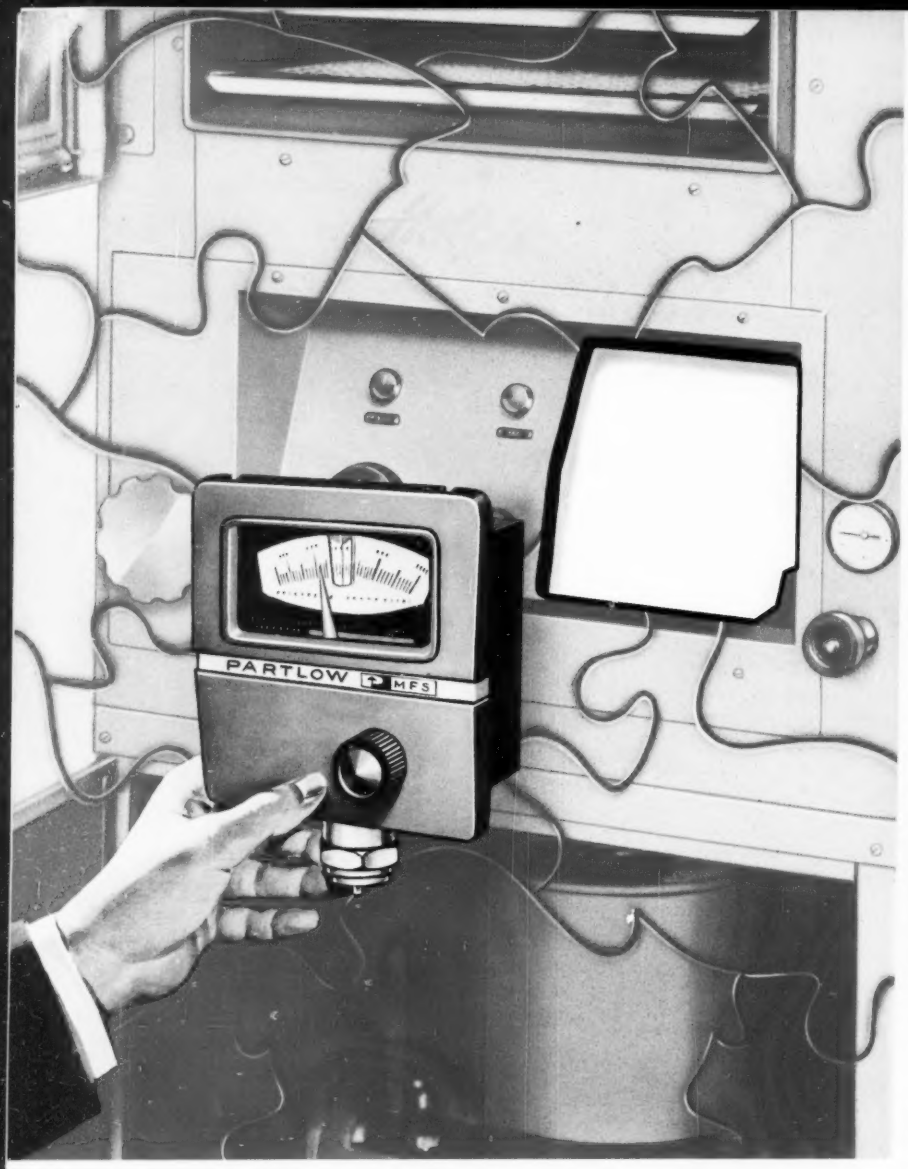
Device	Magnitude	Accuracy (ppm)	Precision (ppm)
Triple-point cell	273.16°K		0.3
Gas thermometer	90.18°K	100	20
Optical pyrometer	3000°K	1300	300

If establishment of a standard for the temperature scale were all there were to temperature measurements, our task would be simple and dull. We must make temperature measurements over a wide range, and we must be able to express our measurements over this range with as great an accuracy as possible in terms of our standard. This led to extensive research in the National Bureau of Standards on phenomena involving temperature and the atomic constants which are needed for measurement of temperatures by Planck's radiation law. Outgrowth of this work involved some of the pioneer precise measurements of the energy levels of excited atoms in the days when Bohr's theory was still an hypothesis.

By taking a physical constant to define our temperature scale we have gained a great deal and lost nothing in precision of temperature measurements. There does not appear to be any better way to establish a standard for temperature. This is not true for all the other prototype standards.

Abstracts from paper The Basis of Our Measuring System, *Proceedings of IRE*, Vol. 47, No. 5, 1959.

CIRCLE 58 ON READER-SERVICE CARD



Partlow makes 25 different indicating control models, including the handsome, high-visibility MFS shown here.

Partlow non-indicating controls give maximum dependability at minimum cost.

A Perfect Fit for Any Temperature Control Application!

Partlow temperature controls today function in an almost infinite range of industrial processes . . . Economically. Accurately. *Precisely!*

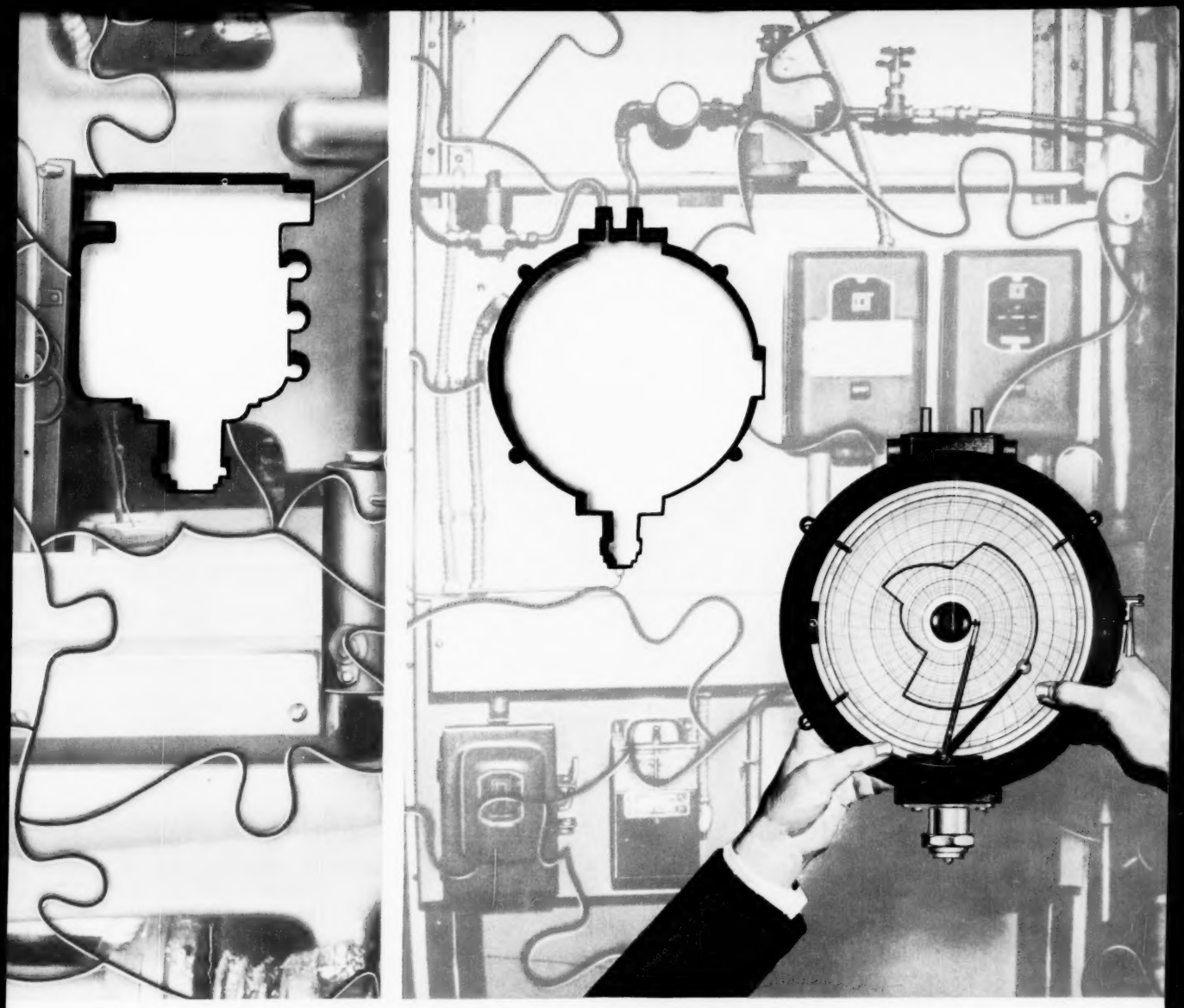
They can perform just as efficiently for *you*.

Partlow controls are actuated by the direct, positive power of mercury, require no mechanical or electronic amplification. Regardless of type, any Partlow you install will stand up to even extreme conditions of shock and vibration . . . without loss of accuracy or sensitivity.

And Partlow makes service headaches a thing of the past! All it takes to replace the Partlow thermal element is a wrench or screwdriver. No 'down time' necessary! The whole job can be done, right at the work site, in a matter of minutes.

If you need accurate, dependable temperature control anywhere within the −70° to 1100°F. range, you'll find a Partlow model to fit your requirements *exactly*.

Get full details without obligation. Fill out and mail the coupon now.



Versatile Partlow recording instruments keep rigid control of process temperatures, and prove it in writing.

Partlow makes the following types of controls and allied equipment for temperatures ranging from −70° F. to 1100° F.:

- **Electric**
- **Mechanical**
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- **Double Pen Recording**
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PARTLOW

TEMPERATURE CONTROLS

THE PARTLOW CORPORATION

New Hartford, N.Y., Dept. A

Please send condensed Catalog of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

Name and Title.....

Company.....

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City and State.....

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TEMPERATURE CALIBRATION SURVEY

Here are the results of a survey made by the Aerospace Industries Association on the question of calibration and standards in the fields of temperature and humidity measurements. Sixty-eight firms were surveyed, most with over 500 empolyees.

Table 1—Temperature and Humidity

NATIONAL BUREAU OF STANDARDS		SUB-CATEGORIES OF MEASUREMENT	REPLIES INDICATE EXISTING ACCURACIES SUFFICIENT		
BEST ROUTINE ACCURACY	RANGE		YES	NO	PROBLEM ACCURACIES
±0.002°C	above 2°K (Footnote A) —carbon thermometer, related to He vapor pressure	TEMPERATURE—			
		Below 4°K	2	0	
"NO MEASUREMENT" (Footnote A)		4° to 12°K	4	1	±.1°K
±0.02°C	12° to 90°K —Pt. resistance therm.	12° to 90°K	7	2	±.03°C (1) ±.005°C (1)
±0.002°C ±0.0005°C ±0.004°C	90° to 273°K (Foot- 273° to 373°K note 373° to 717°K B) —Pt. resistance therm.	90° to 873°K	53	9	±.005°C (3) ±.01°C (2) ±.01°F (2) ±.02°F (1) ±1°K (1)
±0.02°C	717° to 900°K —Pt. resistance therm.				
±0.3°C	273° to 1373°K —Pt. vs Pt-Rh thermocple. (Footnote B)	873° to 1336°K	43	0	
±0.3° to 2°C	1373° to 1723°K —Pt. vs Pt-Rh thermocple.	1336° to 4500°K	24	4	±2°F (2) ±.01% (1) ±50°F for 500-4800 ranges (1)
±3° to 8°C	1336° to 3000°K —Optical Pyrometer				
"NO MEASUREMENT" (Footnote A)		Above 4500°K	1	0	
±2% RH	12% to 97% RH —Saturated Salt Solutions	HUMIDITY—			
±0.5% RH	22% to 98% RH —Pressure Humid. Generator +40°C + —40°C (Footnote C)	Relative	43	3	±2% (2) 5% (1)
±0.1%	1 to 25 mg per liter of dry air (Footnote D)	Absolute (weight of water per unit weight of dry air)	5	2	±2% (1) 1 P.P.M. (1)
±0.1° to 0.2°C	dew point temp: +25°C to —55°C (Footnote C)	Dew point	30	0	

FOOTNOTES

A: Development work is under way in this range.
B: Accuracy column lists maximum uncertainty for indicated ranges; the uncertainty is less near the International Temperature Scale fixed points.
C: Calibration services in this area are not available on a regular basis.
D. Calibration services available after January 1960.

The charted answers for temperature measurement areas placed major activity in the ranges 90°-873°K, 873°-1336°K, 1336°-4500°K. While these ranges are probably not the most difficult to measure they do represent the greatest problem area merely because of the activity in these ranges.

Charting the need for improvement in this category was made difficult by the lack of required accuracies specified by the answering units. Reasons for this column being left blank are hinted at by two answers received—"best available" and "unknown."

It may be of interest to those concerned with temperature measurements to see that four questionnaires claim a present accuracy of 0.01°C while many concerns are specifying that this accuracy or coarser is yet to be achieved. If the demand for these accuracies is realistic, then study must be made to determine if certain organizations are unaware of available equipment and techniques, or whether other concerns are overestimating a device's ability to measure. One company requests, in the 90°-873°K range, an accuracy of ± 1°C. From answers to the questionnaire it seems that this company needs only information to solve its problem.

The variety of terms and designations to indicate accuracies and measurements points out a definite need for standardization in this category.

The table showing how calibration is achieved also points up the differences in techniques utilized in the temperature field.

In the chart of instruments used for temperature measurements, Liquid in Glass Thermometers and Thermocouples are the most popular. Thermocouples were named as being considered most important with Platinum Resistance thermometers next. Unfortunately the "most important" column was misinterpreted by many, with the answerer voting for Steady State or Transient rather than the instrument. This, naturally, reduced the recorded figures.

←CIRCLE 58 ON READER-SERVICE CARD

QUESTION:

(1) If your standards are *not* calibrated by a *higher level* source outside of your company, please indicate what means are used; indicate more than one means if applicable:

18 Round robin cross checks with standards of similar quality in your own company.

3 Round robin cross checks with standards of similar quality in organizations outside of your company.

15 Theoretical calculation and/or error analysis.

10 Depend on the manufacturer's original calibration when standard was purchased.

19 Calibration in terms of some other quantity or parameter represented by a standard of known accuracy.

(2) Indicate whether you use the following types of instruments principally for steady state measurements or for transient measurements. Also, indicate which one of these instruments is of most importance to you in making temperature measurements.

	Use for steady state measurements	Used for transient measurements
Liquid in glass thermometers	56	9
Thermocouples	53	38
Thermistors	14	13
Platinum resistance thermometers	22	9
Optical pyrometers	22	7
Sodium Line Reversal	1	
Millivolt Potentiometers	2	1
Thermobulb Indicators	1	
Gas Thermometers	1	
Resistance Temperature Indicators	1	
RAY O TUBE	1	1
Hydraulic, Solid Expansion		2
Radiation Pyrometers	1	

COMMENTS ON THE AIA CALIBRATION AND STANDARDS SURVEY

R. D. HUNTOON
National Bureau of Standards

In the temperature area, we have already begun to work on most of the problems brought forth in the AIA study. Increased effort will be devoted to them in Fiscal Year 1960 and a great increase of effort should be provided for 1961 and succeeding years.

Cryogenic or low-temperature range: No NBS calibration service is available in the range from 4 to 12°K at present, but work now planned should enable us to provide some standards by 1961. In the range from 12 to 90°K two attacks are underway: (1) We are attempting to develop better techniques for making measurements of thermodynamic temperatures in this region; and (2) we are working to develop precise, reproducible techniques for laboratory and industry use which should enable us to extend the International Temperature Scale down to these lower temperatures. At present the International Temperature Scale stops at 90°K. However, the problems here are difficult and results come slowly.

High-temperature range, 1336 to 4500°K: Some of the problems listed in the AIA report for this range look as if they could be solved by an extension of existing techniques. In FY 1960 we are planning to build and put in operation a photoelectric standard pyrometer we hope will give the desired accuracies—as indicated in the AIA survey—up to perhaps 3,000°K (roughly, 5,000°F). A greatly expanded program of research is needed if we are to provide, within a short time, high-temperature sources and standards up to 12,000° K, and even this will only equal present Russian capabilities.

Abstracts from talk presented at N. Y., Aug. 1959

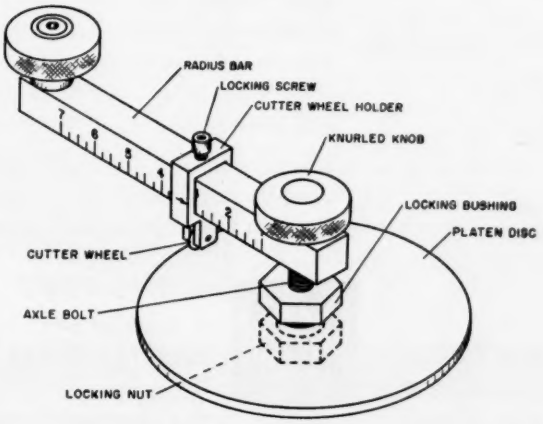
CUTTING HOLES IN SHEET METAL

R. L. FARR
Goodyear Atomic Corporation

THE device shown was used to cut clean, right-angle, circular holes in instrument panels to accommodate pressure gauges, dials, etc.

A 1"-diameter hole is punched or drilled in the center of the circular area to be cut out of the sheet metal stock. A locking bushing, which has an axle bolt screwed into the center, is placed in this hole and a locking nut is screwed onto the bolt to hold the sheet metal securely. Whenever the sheet metal is too thin or too flexible to resist the applied cutting force, a platen disk, which is ⅛" smaller in diameter than the hole being cut, is placed between the stock and the locking nut to absorb the force. A wooden disc is used when it is necessary for the cutter wheel to ride over the platen.

A radius bar is manually rotated about the axle bolt and pressure is applied on the cutter wheel by tightening a knurled knob on the axle bolt. By repeated circular arc movements a clean, right-angle, circular cut is achieved in sheet metal stock up to ⅛" thick.



accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

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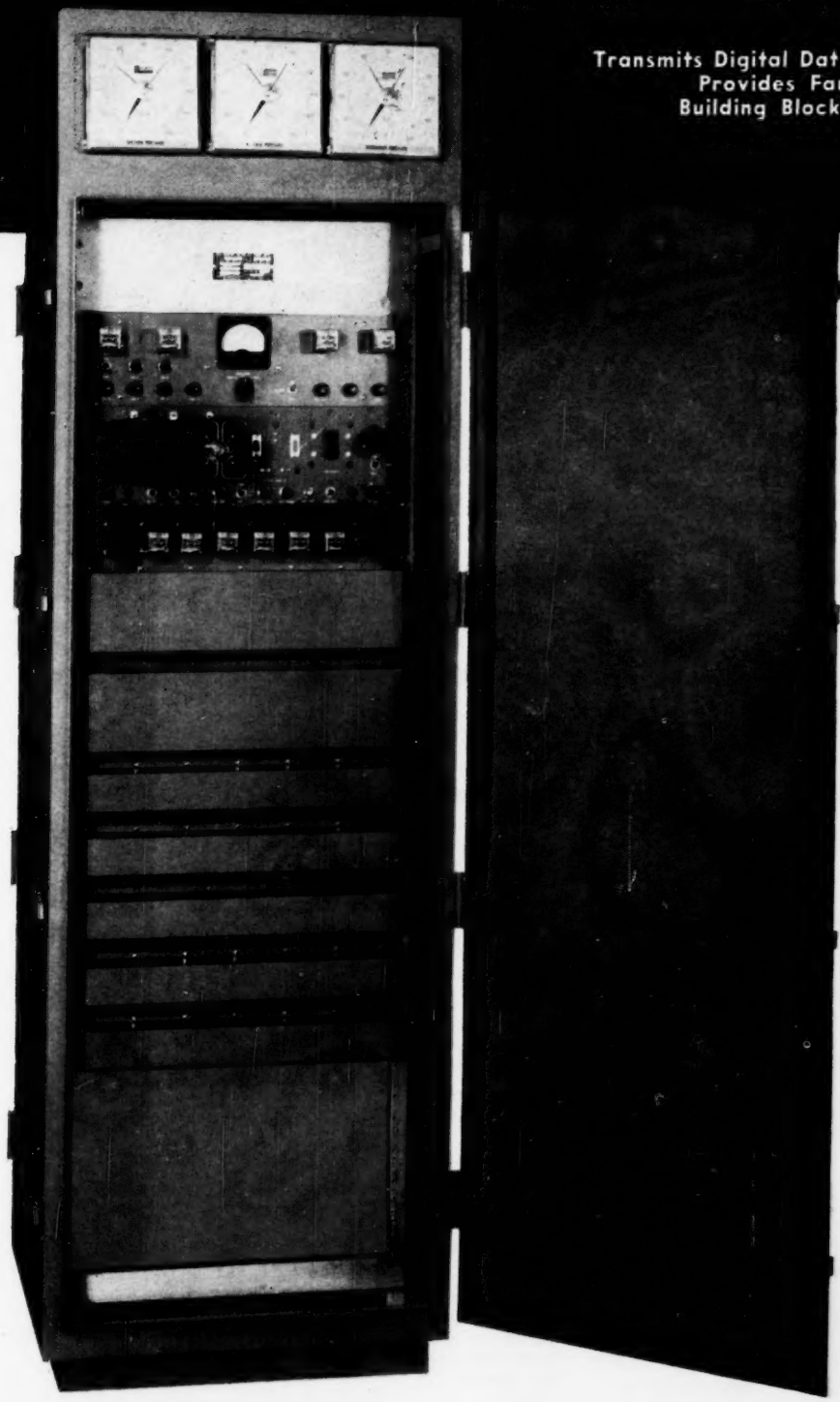
CIRCLE 59 ON READER-SERVICE CARD

CIRCLE 60 ON READER-SERVICE CARD →

DATRANSYST
DIGITAL DATA TRANSMISSION SYSTEM



Transmits Digital Data in Teleprinter Code
Provides Fault Checking
Building Block Construction

The Datransyst Digital Data Transmission System provides means for fully utilizing standard teleprinter circuits for digital data transmission. The received data may be used to operate digital displays, to control functions, or to perforate tapes or cards. As the system is completely compatible with standard teleprinter operations, a single teleprinter can be used for service messages or to "log" incoming data. Standard teleprinters can also monitor the transmissions en route. The building block construction of the system facilitates the arrangement of the various elements to accommodate the requirements to a wide range of applications, such as data transmission for pipe line operations, supervisory control systems, traffic control, centralized inventory control systems, and many others.

TELEMETERING

Signals from coding discs or other coding elements, or from analogue to digital converters, are accepted and translated into standard teleprinter signals. Several different types of codes may be supplied to the system, which then contains individual translators for each code.

Automatic fault checking can be supplied by a system of dual transmission. All characters are sent twice, their received code combinations are compared, and only those characters registering the identical code in both transmissions are printed or displayed. Faults will be identified by individual digit alarms, or by returning a complete group of digit displays to 000, or by special customer selected indications. When a logging teleprinter is used it indicates errors by printing special characters.

PROTECTED TELEGRAPH CIRCUIT

The system can be arranged for providing complete protection of the transmission of telegraph information over wire or radio communication systems against errors caused by interference or defects in the transmitting medium.

SUPERVISORY CONTROL AND TELEMETERING SYSTEMS

Supervisory control and telemetering systems are designed with the building blocks of the Digital Data Transmission System. Such systems can be supplied to provide supervisory control over a number of field stations from a master station, and to provide for telemetering data back to the master station from a field station. Error free transmission of all control information and telemetered data can also be provided.

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RESEARCH • DEVELOPMENT • DESIGN • MANUFACTURE OF SPECIALIZED EQUIPMENT

FIG. 1. THERMAL AREA of Electro-Mechanical (EM) calibration laboratory.

THE TEMPERATURE STANDARDS LAB

Here are the instruments used and the resultant measurement accuracy capabilities of one of the country's finest standards and calibration facilities

CHARLES E. WHITE
AVCO Research & Advancement Development

TABLE 1—TEMPERATURE INSTRUMENTATION LIST

Note: Mention of company does not mean endorsement. Instruments are available from several sources. The user should check all sources for latest developments.

ITEM	MANUFACTURER AND MODEL	APPLICATION
Bath, Circulating & Tank	LUB L-154 + KS	EM34
Bath, Cooling	CO3	EM34
Bath, Liquid	CO3	EM34
Bath, Ultra-Thermostat	LUB L-154 + L-150/3	EM34
Bridge, Mueller, G1	LEA 8067	EM36
Bridge, Mueller, G2	LEA 8069B	EM27
Bridge, Portable Temperature	LEA 8062	EM0
Calivolter	CAB A23	EM0
Cathetometer	GAA	EM0
Cathode Follower	COQ 4000	EM0
Cell, Std. Volt—Unsat.	EPA 100, 103	EM0
Cell, Triple Point	TRS 130	EM19
Controller, Pyrovane Vert.	BRH 105C4-13/110	EM21, 22, 23, 24
Controller, Pyrovane Vert.	BRH 105C4-13/220	EM25, 26
Crusher, Ice	FIB 800	EM0
1 Furnace, HiTemp	JOJ JMCK 25—B + C8BL	EM37
4 Furnaces, Melting Point	TRN C7565/110	EM21, 22, 23, 24
2 Furnaces, Melting Point	TRN C7565/220	EM25, 26
1 Furnace, Steam Point	TRN D7592/110	EM20
1 Furnace, Thermocouple Test	HOA FA 300-46	EM37
Galvanometer, Reflecting	RUA 3202	EM0
Galvanometer, Spotlight	LEA 2430-A, C	EM0
Galvanometer, Spotlight	RUA 3402	EM0
Immersion Heater	WAN SF	EM34
Inverter	BRK 4610	EM0
Lab Jacks	CEH 19086, 19089	EM0
Meter, Capacitance	AVB CM	EM0
Oscilloscope	HEA 130A	EM0
Potentiometer, K-3	LEA 7553	EM 35, 38
Potentiometer, Thermocouple	RUA 2745	EM0
Potentiometer, Thermofree	RUA 2768	EM35, 38
Regulator, Thermo	HBA 7940-A	EM0
Rheostat	BIA DD-2.4	EM0
Rheostat	HOA HFD-203	EM37
Temp Chek	WEE 60-80°F; 60-100°F	EM0
Thermo-Humidigraph	BRC F4069TH	EM0
Thermometer, Lab.	HBA 19°-21°C	EM0
Thermometer, Liquid	CEA RSCL & 19332-D	EM0
Thermometer, Plat. Res.	LEA 8163-B	EM18, 30
Thermometer, Precision	PRF 76-3, 76-4	
Thermometer, Resistance	MAL MAN	EM0
Thermos	AMZ 8642	EM0

TABLE 2—TEMPERATURE MEASUREMENT ACCURACY CAPABILITIES

VARIABLE	RANGE	ACCURACY	STANDARD
Temperature			
Fixed Points	+0.010°C abs.	±0.0005°C	Triple Pt. Cell & Res. Thermometer
	+100.000°C abs.	±0.001°C	Steam Bath & Res. Thermometer
	+231.88°C	±0.01°C	Freezing Pt. of Tin & Res. Thermometer
	+327.40°C	±0.01°C	Freezing Pt. of Lead & Res. Thermometer
	+419.50°C	±0.01°C	Freezing Pt. of Zinc & Res. Thermometer
	+660.0°C	±0.2°C	Freezing Pt. of Aluminum & Thermocouple
	+960.5°C	±0.2°C	Freezing Pt. of Silver & Thermocouple
	+1083.3°C	±0.2°C	Freezing Pt. of Copper & Thermocouple
Intermediate points	−183°C — +630°C	±0.02°C	Resistance Thermometer
	+630°C — +1100°C	±0.5°C	Thermocouples
	+1100°C — +1450°C	±1°C — ±2°C	Thermocouples

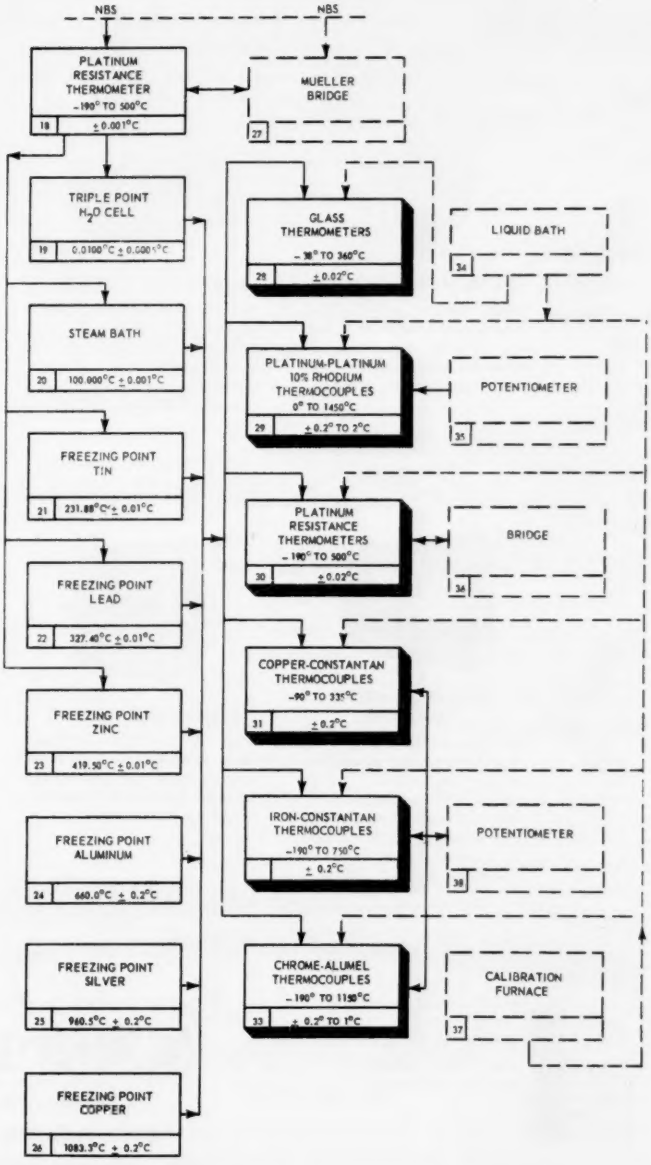
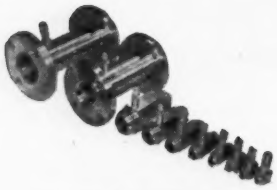


FIG. 2. TEMPERATURE MEASUREMENTS flow chart with accuracies noted. The EM numbers in Table I refer to the numbers in lower left corners of each block. For example, triple point cell is used in application EM 19, referring to electro-mechanical test 19. The designation EM0 in table I means that the unit has common usage in several applications.

TABLE 3—CODE OF MANUFACTURERS

AMZ—American Thermos Products Co., Norwich, Conn.
AVB—AVCO, R.A.D., Wilmington, Mass.
BIA—Biddle, James G., Philadelphia, Penna.
BRC—Bristol Co., Waterbury, Conn.
BRH—Brown Instrument Div., Philadelphia, Penna.
BRK—Bruel & Kjaer, Cleveland, Ohio
CAB—Calidyne Co., Winchester, Mass.
CEA—Central Scientific Co., Chicago, Ill.
CEH—Cenco Lerner, Cambridge, Mass.
COQ—Columbia Research Labs, Woodlyn, Penna.
CO3—Columbia Electric Mfg. Co., Cleveland, Ohio
EDA—Edison Co., T. A., Orange, N. J.
EPA—Eppley Labs, Inc., Newport, R. I.
FIP—Fisher Scientific Co., Pittsburgh, Pa.
GAA—Gaertner Scientific, Chicago, Ill.
HBA—H B Instruments, Phila., Pa.
HEA—Hewlett Packard Co., Palo Alto, Calif.
HOA—Hoskins Mfg. Co., Detroit, Mich.
JOJ—Johnson & Matthey, England
LEA—Leeds & Northrup, Philadelphia, Penna.
LUB—Lux Scientific Inst. Co., New York, N. Y.
MAL—Manostat Corp., New York, N. Y.
PFR—Precision Thermometer & Instrument Co., Brooklyn, N. Y.
TRN—Trent Co., Philadelphia, Penna.
TRS—Transonics, Inc., Lexington, Mass.
WAN—Waag Electric, Inc., Kennelworth, N. J.
WEE—Webber Gage Co., Cleveland, Ohio

Flow Meters



TURBINE FLOWMETERS

Accuracy ½% of reading. Ranges 0.01 to 10,000 gpm. Single bearing design, easily disassembled for cleaning without affecting calibration. Readouts shown below.

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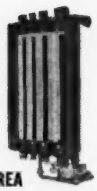

VARIABLE AREA

Flowmeters, accuracy ½% and 1% of reading. Single and multiple stages. For air, oil, water, fuel. Ranges 5 to 130,000 pph.

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FLOW NOZZLES

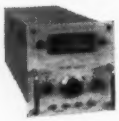
For air and liquid flow. Made to A.S.M.E. specifications. Twenty sizes available.

Request Bulletin 1392-A

FLOW MEASUREMENT

There is a Cox Instrument for just about every flow measurement requirement. Since 1912 Cox has been a pioneer in the development of *precision* measuring instruments. Cox application engineers are available to assist you on any flow measurement requirement.

Electronic Flow Indicators



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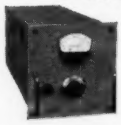

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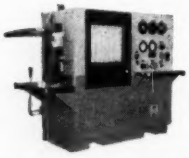

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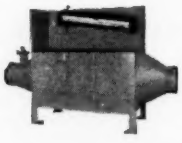

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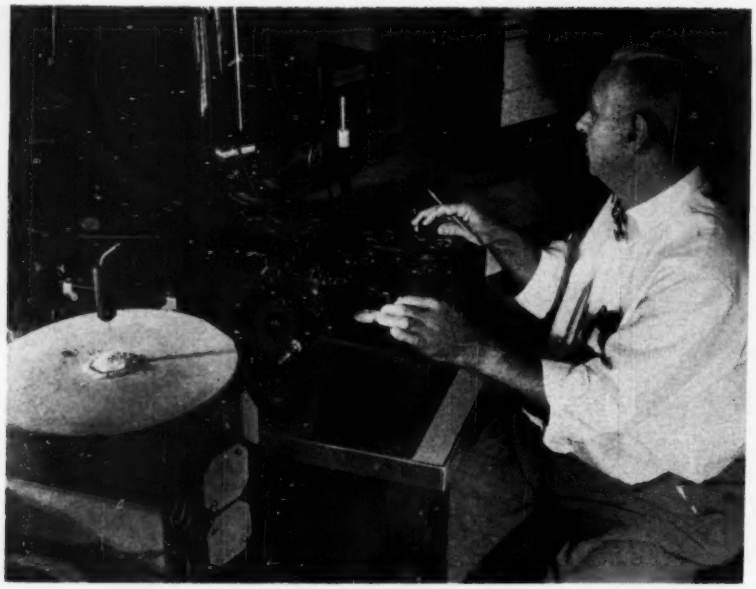

FIG. 1. STANDARDIZING a platinum resistance thermometer at a freezing point with a Mueller bridge.

Temperature Standards at GE

S. C. RICHARDSON
General Electric Company

The temperature standards of the General Engineering Laboratory of the General Electric Company include fixed points at the melting, freezing and boiling temperatures of pure elements and compounds. These are used to certify resistance thermometers and thermocouples. High-temperature standards include optical pyrometers and tungsten lamps.

TEMPERATURE STANDARDS at the reference level consist of a group of fixed-point references which are primary and secondary points of the International Scale of 1948. These fixed points are the melting, freezing, or boiling temperatures of pure elements or compounds. High-purity metals are used which are obtained either from NBS or metal refiners specializing in this field. The principal application of these fixed-point standards is for the testing and certification of platinum resistance-thermometers and platinum to platinum-rhodium thermocouples.

Certification of Resistance Thermometers

The platinum resistance-thermometers are measured at three fixed-point temperatures (normally the ice, steam and sulphur boiling points), and the resistance value determined by measurement on a temperature-controlled Mueller-type resistance bridge (Fig. 1). By simultaneous solution of the three equations thus obtained, the constants of the quadratic formula expressing the temperature-resistance relationship of the thermometer are derived. Using these constants, the ratio of the resistance at a given temperature to the resistance at the ice point is machine tabulated every C° over the range of −50° to +550°C.

The ratio change per degree also is tabulated so that interpolations can be made readily. The Mueller-type bridge is completely checked annually by coil comparisons to the nearest 0.0001 ohm. While it is only the *ratio* of these coil values that is of prime importance, an absolute-value measurement is made by comparison against a 10-ohm group of reference resistors. This measurement establishes a stability record on the bridge coils.

Certification of Thermocouples

The platinum to platinum-rhodium thermocouples are tested at the freezing-point temperatures using a five-dial precision potentiometer that measures to the nearest microvolt. Such thermocouples are normally tested at the freezing points of antimony, silver and copper (Table 1). The values of the constants of this quadratic expression also are determined by the solution of simultaneous equa-

Abstract from ISA Preprint 9-59

TABLE 1—REFERENCE-LEVEL TEMPERATURE STANDARDS

Fixed Point	Temperature °C
Melting Point of Ice	0.000
Triple Point of Water	0.0100
Boiling Point of Water	100.000
Benzoic Acid	122.361
Tin	231.91
Cadmium	321.03
Lead	327.40
Zinc	419.50
Boiling Point of Sulphur	444.600
Antimony	630.50
Silver	960.8
Copper	1083.2

tions and values are calculated for the output emf every 100°C from 600°C to 1100°C. Corrections then can be determined for any particular thermocouple standard in terms of the NBS reference tables.

Reference Contamination

The fixed points are reference level standards; it is only necessary to ascertain that the sample contamination is negligible and, for the pressure-dependent points, that there is no significant pressure error. Duplicate platinum resistance-thermometers and platinum to platinum-rhodium thermocouple standards are maintained in terms of the fixed reference temperatures. One of each of these standards is sent to the National Bureau of Standards for certification on a 3-year basis as a cross-check on reference-point contamination.

Two years ago this check indicated a possible slight contamination of the silver point which had been in use over twenty years. A new silver sample of less than 1-ppm impurity was obtained and tested. It differed in freezing-point emf by only 1 microvolt from the old silver. This is indicative of the stability of fixed-point samples when they are kept free of contamination.

High-Temperature Standards

The temperature standards at higher temperature levels consist of a three-range optical pyrometer of the potentiometer type, standardized to 2800°C, and two tungsten-strip filament lamps that are standardized in terms of brightness temperature versus current to 1800°C. The accuracy of these standards is maintained by intercomparison and by alternate NBS certification of the pyrometer and one of the lamps.

Counter Automates a Tensile Tester

MODERN tensile-testing machines not only weigh the forces on sample materials but also control the rate of extension. Researchers can look beyond the simple stress-strain curve into some of the rheological or time-dependent properties of a material—the detailed shape of a stress-strain curve, and the importance of such properties as stress relaxation, recoverable and non-recoverable creep, stress recovery, and mechanical hysteresis.

Versatility in the testing function requires complex loading histories under conditions in which the time element is rigidly controlled. In many types of repetitive-stress testing there is need for a moderate degree of automation because the repetition alone placed an intolerable burden on human patience and accuracy of observation.

A Veeder-Root counter was incorporated recently in an Instron testing machine to control cycle testing and other functions of this type of control. The counter is an electrically-operated predetermining-type with automatic reset, adding little to the over-all cost of the testing machine, but increasing its versatility and usefulness. In operation it may be preset for a desired number of tension-to-zero or tension-through-zero-to-compression cycles, or for any desired count of similar functions. Its circuitry provides a means for shutting down the machine after a given number of cycles, or when rupture occurs, or on a signal indicating when a specific stress limit, resistance, modulus change, or other measurable stimuli has been reached. Detailed evaluation of a relatively complex test may be made by an operator or other person who is not even present during the testing phase; completely detailed results may be obtained from a machine which may have operated unattended over an extended period of time.

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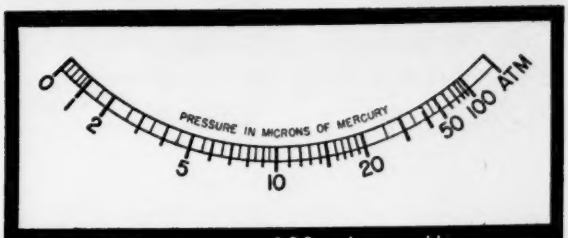

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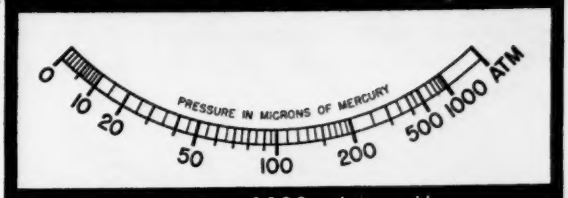
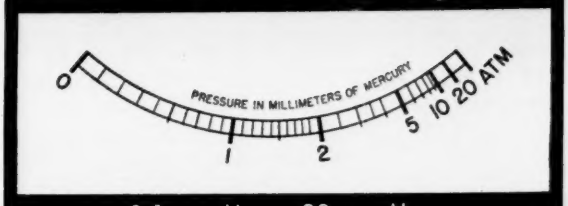


1 micron to 1000 microns Hg



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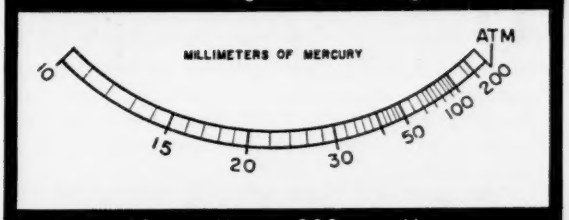

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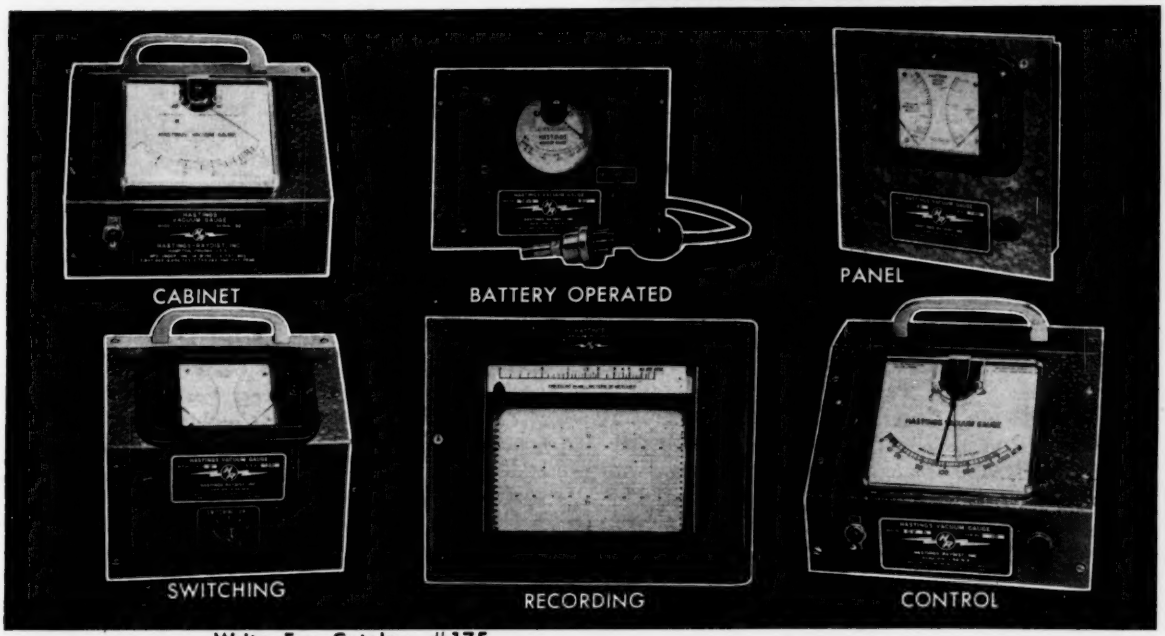

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Resistance

FIG. 1. RESISTANCE temperature detectors. Miniature unit (fourth from left) has diameter of 0.278 inch and length of 0.25 inch.

OF THE three common non-radiation-type electrical temperature-sensing devices available to instrument engineers for remote temperature measurement—thermocouple, resistance temperature detector and thermistor—the resistance temperature detector has certain inherent advantages.

The precision, accuracy and stability of the platinum resistance temperature detector is so great that it was selected in 1927 to define the International Temperature Scale from −190°C to +660°C. Precision (laboratory) platinum resistance temperature detectors can measure to accuracies as close as a few thousandths of a degree Fahrenheit.

Industrial, hermetically-sealed resistance temperature detectors "drift" less than 0.05% over five years of continuous use. Their use simplifies instrumentation by permitting the use of higher levels of output power (per degree change in temperature) than is available from either thermocouples or thermistors. They are more versatile than thermocouples because either a-c or d-c signals can be used.

Principle

The principle of operation of resistance temperature detectors is based on the fact that the electrical resistance of metals increases directly with temperature, and is reproducible to a high degree of accuracy. The term used to express this characteristic is known as *the temperature coefficient of resistance* and is defined by the approximate formula $R_t = R_o\ (1 + \alpha t)$ where α is the temperature coefficient of resistance, R_o the resistance of the wire at 0 degrees C, and R_t the resistance at any other temperature t.

Resistance thermometry had its beginning in 1887 when H. L. Collendar published a paper "On the Practical Measurement of Temperature." He described the essential elements required in precise resistance thermometry—a resistance winding properly mounted and protected, a means of measuring the resistance, and a known relationship between resistance and temperature.

Until World War II high purity metals were expensive and difficult to obtain, confining the use of these detectors to laboratory work. During the last fifteen years, however, high-purity metals have become available generally and manufacturers now offer resistance temperature detectors in a multitude of configurations for general and special industrial uses.

Materials

Many metals (Table 1) can be used as the sensing elements of resistance temperature detectors; the most common are platinum, nickel, copper and tungsten.

Primary considerations in choosing a metal for the element of an RTD are the *temperature coefficient* of resistance of the metal (which should be as high as possible), its *electrical resistivity* (which also should be as high as possible) and its *metallurgical properties* (its ability to withstand contamination, its strength at high temperature, and the reproducibility of both the temperature coefficient of resistance and the resistivity).

Platinum has a reasonably high resistivity, a high melting point and a relatively large temperature coefficient of resistance; it is a noble metal and its resistance varies very nearly linearly with temperature. Although platinum is thought of as expensive, only small amounts of wire are actually used.

Nickel also is an attractive metal for resistance

VICTOR W. ROSE
Thomas A. Edison Industries
Instruments Division

Temperature Detectors

thermometry. Its temperature coefficient of resistance is high; it is easy to obtain in a pure state; it is in-expensive and easy to work.

Copper has been used for many years to make resistance temperature detectors and is still used to some extent for measuring stator winding temperatures of motors and generators. However, as it has an extremely low resistivity (so that long lengths of wire are required to form the sensing element) and as measuring accuracy is adversely affected by the resistance of the wiring to the instruments, the use of copper is limited.

Gold and *silver* are not used much because they have a low resistivity.

Tungsten has a high resistance and a good temperature coefficient but is difficult to work.

Design

Resistance temperature detectors for industrial use generally consist of a wire sensing element suitably mounted in a protective housing or well, with internal wires from the element to suitable terminals or connections, from which ordinary copper wires may be run to the measuring indicator, recorder, controller, or associated instrumentation.

The wire size commonly used for the sensing element may vary from 0.002″ to 0.020″ in diameter, and the length of wire required is determined by the desired basic resistance at 0 degrees C (or at any desired temperature). This resistance may vary from 0.5 ohm for special laboratory-type resistance temperature detectors to many thousands of ohms. For general industrial use it is generally between 10 ohms (for copper RTD's) and 1000 ohms (platinum or nickel), depending on the design requirements. As a number of manufacturers presently mass-produce industrial RTD's, several standards for basic resistance already exist, such as 10 ohms, 50 ohms, 90.38 ohms, 100 ohms, 120 ohms and 600 ohms at 0 degrees C. Resistance

TABLE 1—MATERIALS USED AS RESISTANCE TEMPERATURE DETECTORS

Metal	Temperature Coefficient of Resistance	Electrical Resistance Per Circular Mil Foot
Platinum	0.00392	59.00 ohms
Nickel	0.00672	36.00 ohms
Copper	0.0038	9.26 ohms
Tungsten	0.0045	30.00 ohms
Gold	0.0040	13.00 ohms
Silver	0.0041	8.80 ohms

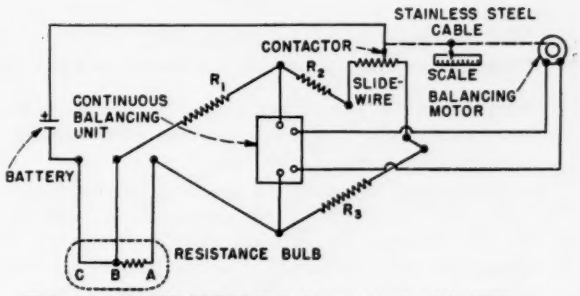


FIG. 2. CONVENTIONAL bridge circuit with RTD. (Courtesy Brown Instruments Div., Minneapolis-Honeywell Reg. Co.)

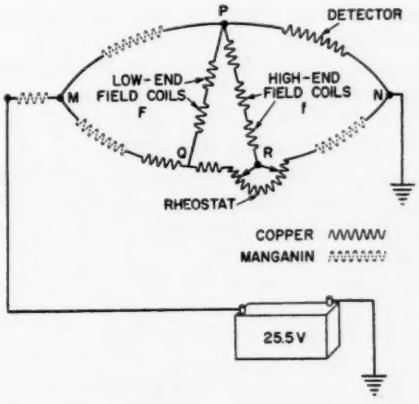
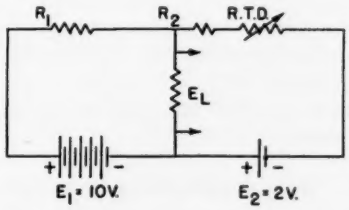


FIG. 3. RATIO METER bridge circuit, using crossed-coil movement, is independent of variations in source potential.



NOTE: R_2 = LEAD WIRE RESISTANCE

FIG. 4. BRIDGE with two sources features excellent linearity.

TABLE 2—COMPARISON OF ELECTRICAL TEMPERATURE-SENSING DEVICES

	RTD	THERMOCOUPLE	THERMISTOR
Accuracy (Repeatability)*	0.05°F to 0.1°F	2°F to 15°F	0.2°F to 2°F
Stability*	Less than 0.10% drift in five years	1° to 2° drift in one year	0.2°F to 5°F drift in one year
Sensitivity*	0.2 to 10 ohms/C°	10 to 50 microvolts/C°	100 to 1000 ohms/C°
Interchangeability	±0.5%	±0.75%	±0.5% (3% without selection)
Temperature Range	—200° to 1600°F	—300°F to 3100°F	—150°F to 550°F
Signal Output	1 to 6 v	0 to 60 mv	1 to 3 v
Power (with 100-ohm load)	4×10^{-2} watt	1.6×10^{-5} watt	8.1×10^{-1} watt
Minimum Size	9/32" dia. x 1/4" long	0.015" dia**	0.014" dia.
Unique Features	Greatest accuracy over wide spans; very stable.	Greatest economy; has highest range.	Greatest sensitivity (most accurate for short spans); high impedance minimizes lead effects.

* This data varies with range and point on scale.

**Chromel-Alumel wire is available in sizes down to 0.0007" dia.

temperature detectors purchased to these basic resistances will cost less than detectors having special basic resistance values.

Most nickel or platinum detectors are made of wire 0.002″ to 0.006″ in diameter, and of a length to give a basic resistance of 50 to 600 ohms at 0 degrees C. This results in a length of wire for the element of from approximately 5′ to 50′, a length which can be wound into a sensing element small enough for practical use in wells similar to those used for thermocouples. Miniature nickel-resistance temperature detectors only 0.278″ in diameter and ¼″ long, having a resistance of 120 ohms at 0 degrees C, are being built on a commercial basis for general industrial use. These detectors are interchangeable electrically with larger detectors for use in thermowells.

Basic Circuitry

Because resistance temperature detectors are electrical resistors they are usually used in Wheatstone bridge circuits, the detector forming one leg of the bridge. Fig. 2 shows a conventional circuit in which the output of the bridge is used to drive an indicator. A bridge with no RTD's can be used to record temperature differential.

The *ratio meter* bridge circuit (Fig. 3) is used in Edison instruments. The indicator has a magnetic vane pivoted between two pairs of stationary field coils (F and f), connected as shown. As the meter reading depends on the ratio of emf's across the coils, it is independent of the emf of the source, thus eliminating a possible source of error.

Bridge circuits can provide a linear voltage output by proper choice of resistance values. For example, a bridge with only 6-volt source can give linear output of from 2 to 5 volts.

Linear output also can be obtained by using two voltage supplies (Fig. 4).*

Advantages and Limitations

The advantages and limitations of resistance temperature detectors compared with other types of thermometers are shown in Table 2. The principal advantages of resistance temperature detectors are their (1) large power output when used in bridge circuitry, (2) stability and accuracy over years of use and (3) reproducibility.

One of the principal advantages gained through the use of resistance temperature detectors is the simplification of the instrumentation. Potentials of from 1.0 to 6.0 *volts* may be applied directly across the resistance temperature detector, affording sufficient power to operate indicators or relays directly.

The stability and reproducibility of platinum resistance temperature detectors is better than any other known temperature-sensing device in the range of —190° to +660°C.

Hermetically sealed resistance temperature detectors do not drift more than 0.05% from their basic resistance over a period of five years of usage, while thermocouples become less stable with aging and thermistors "drift" initially, becoming more stable with use. It should be noted that the higher the temperature the greater the "drift" experienced with thermistors, with 580°F being the highest operating temperature recommended.

The principal limitation of industrial resistance temperature detectors is their physical size. In order to have a basic resistance high enough so that the resistance of the wiring to the instrumentation will not be an appreciable factor, about ten feet of wire is required for the sensing element. The use of 0.002″-diameter wire and improved techniques has resulted in detectors as small as 0.278″ in diameter by ¼″ long.

In employing resistance temperature detectors for extremely precise temperature measurements, care must be taken to keep the power dissipated by the sensing wire to a minimum in order to prevent the temperature of this element from rising above that of the medium being measured.

The *response* of any temperature detector is always slowest when the medium being measured is a gas having zero or low velocity relative to the detector, and fastest in liquids which move rapidly past the detector.

The response time (lag factor) of an RTD can be minimized by proper detector design—the use

*See article The Asymmetric Bridge, A. Kaufman, March *I&CS*.

of high ratios of surface area to mass, the elimination of high thermal-resistance paths between the sensing wire element and the detector surface, and the use of materials having a low product of specific heat and density.

The fast response times of thermocouples and/or thermistors pertain to bare laboratory units; when mounted in similar industrial housings (such as wells) all three types of elements have approximately the same response time (from 0.1 to 10 seconds) due to the well time constant.

Uses

Industrial resistance temperature detectors are made in a wide variety of physical configurations depending on their intended use (Fig. 1). *Tip-sensitive detectors* (Fig. 5) are used to measure the temperature of solids such as the bearings of machinery, tank surfaces, platen or mold temperatures. *Stem-sensitive detectors* (Fig. 6), are used to measure the temperature of liquids or gases. These detectors are usually designed so that the element is extended over the length of the stem of the detector in order to read the average temperature of the medium being measured. They are generally hermetically sealed in their own well to protect the sensing element from corrosive fluids and to preclude the need for an additional thermowell, thereby increasing the speed of response.

Detectors having heavy wells capable of withstanding as much as 15,000 psi are available for high-pressure temperature measurements.

Where fast response is required, the well is flattened or machined to a thin wall section. This increases the ratio of surface area to mass and reduces the response time in some designs to values below one second. Detectors for use where nuclear radiation is present can be constructed of materials little affected by such radiation.

One advantage peculiar to resistance temperature detectors is that they are particularly suited to measuring the *average temperature* of a liquid or gas. The element can be strung out for the full depth of a petroleum storage tank, for example, to read the average temperature, which might vary at different levels within the tank. Other applications are to measure flue gas temperature and condenser cooling-water temperatures.

Platinum-wire resistance temperature detectors are used for temperatures exceeding 600°F, for precise differential temperature measurements where linearity is important, and where extremely precise temperature measurements are required. For general industrial use in chemical plants, petrochemical plants and refineries, where extreme vibration and shock may be expected at high temperatures, platinum-resistance temperature detectors are generally limited to 1350°F. However, in less severe environments, platinum detectors can measure temperatures as high as 1600°F.

High-Temperature Resistance Thermometry

(The following is taken from NBS Summary Technical Report STR-2420)

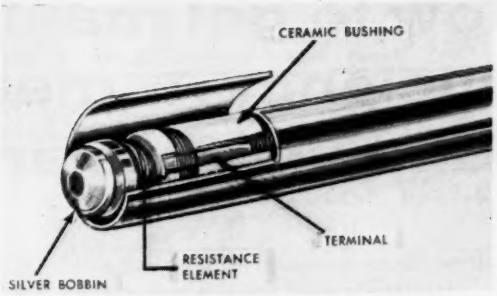


FIG. 5. TIP-SENSITIVE detector.

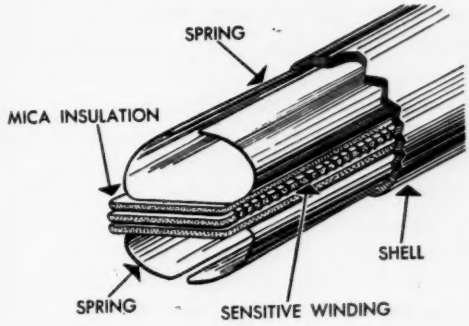


FIG. 6. STEM-SENSITVE detector.

The International Temperature Scale is presently defined, for the range 630.5° (melting point of antimony) to 1063°C (melting point of gold) in terms of a platinum versus platinum-rhodium thermocouple. This instrument, however, can measure with an accuracy of only a few tenths of a degree. The platinum resistance thermometer is presently used at temperatures below 630.5°C; extension of its range to 1063°C, to replace the thermocouple, would not only provide greater precision, but would also simplify and smooth the scale.

Experiments at NBS show that it is possible to construct platinum resistance thermometers which have drifts of less than 0.001 degree per hour at 1000°C. To achieve this stability, it was found necessary to use platinum wire of the highest available purity for the temperature-sensing resistor, to support the resistor in a strain-free manner, and to use materials containing no silica for support and protection.

The problem of determining accurately the resistance of the thermometers is also being investigated. As part of this study, an improved Mueller resistance bridge was designed at NBS. Under evaluation at NBS is a potentiometric method of resistance determination which is independent of the lead resistance changes caused by varying temperature gradients along the thermometer.

References

1. E. F. Mueller, "Precision Resistance Thermometry," *Temperature, Its Measurement and Control*, Reinhold Publishing Co.
2. Wm. F. Roeser, "Thermoelectric Thermometry," *Temperature, Its Measurement and Control*, Reinhold Publishing Co.

How to get maximum combustion efficiency . . . measure <u>both</u> combustibles and oxygen

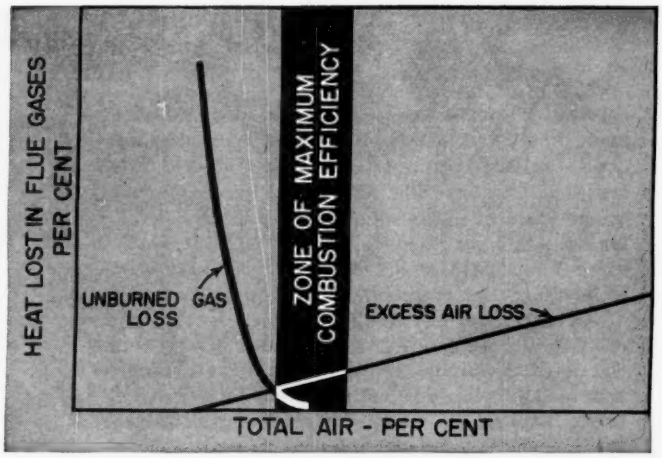
Simultaneous measurement of both oxygen and combustibles is needed to obtain optimum combustion. No instrument that measures only one of these two interdependable factors can give you the full information necessary.

Now, Bailey offers two units, each giving a continuous and simultaneous double check on combustion efficiency: a permanent analyzer-recorder which records both factors on a single chart; and a new light weight, portable unit which indicates both factors.

Both instruments measure: (1) excess air—regardless of the fuel or combinations of fuel being burned, (2) mixing efficiency of your fuel burning equipment by showing per cent combustibles in the flue gas.

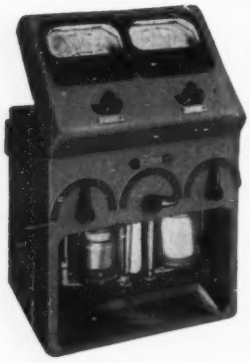
Both units are designed to increase efficiency in the furnace operations of the steel industry, on glass tanks, cement and lime kilns, ceramic and refractory kilns, steam boilers and also on direct and indirect-fired furnaces in the metal processing industries.

To prevent your money from becoming waste gas, look into these two efficiency provers. A Bailey engineer will be glad to give you details or write us for product specifications.


HEAT LOST IN FLUE GASES PER CENT
UNBURNED GAS LOSS
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
EXCESS AIR LOSS
TOTAL AIR - PER CENT

Maximum Combustion Efficiency is secured by keeping the sum of Excess Air Loss and Unburned Gas Loss to a minimum. To do so by the direct method simply measure both oxygen and combustibles in flue gas.

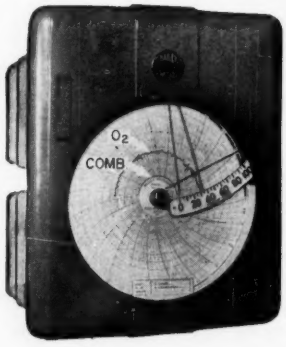
For portable use—
HEAT PROVER Analyzer



The famous Cities Service HEAT PROVER analyzer is now Bailey built and sold. Weighing only 25 pounds, it is a self-contained automatic analyzer including a sampling tip and hose plus a thermocouple for temperature measurement.

Instrument dials are dual range for greater accuracy and sensitivity.

For permanent installation
Oxygen-Combustibles Recorder



The Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart. These records enable the operator to keep fuel burning equipment performing continuously in the zone of maximum combustion efficiency. Excess air may be reduced to the point where combustibles begin to show.

G 40-1

Instruments and controls for power and process

BAILEY METER COMPANY

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BAILEY METERS

CIRCLE 65 ON READER-SERVICE CARD

HOKE Flow Sheet 2

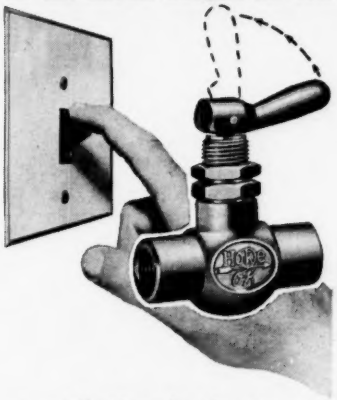
HOKE REPORTS ON FLUID CONTROL

WE'VE PACKED PERFORMANCE IN A PACKLESS VALVE

How to be "Flip" About On-Off Control

We've turned the tables on electrical engineering profs who try to demonstrate current flow by describing a valve on a pipe. Our switch-action toggle valves stop and start flow just as easy as: Flip, it's on! – Flip, it's off!

These valves perform a basically simple function, but a lot of engineering went into them to insure perfect performance. Many are used on precision test equipment and for control applications, often in conjunction with automatic controls as a manual safeguard for fast shut-off. Designed for both



gas and liquid service, the stem seals are tight enough for most vacuum work, too. We certainly can't be flip about these specifications.

Hoke manufactures two types of toggle valves. The 450 Series has maximum operating pressures up to 200 psi. These are spring closing valves made in ¼" and ⅛" pipe sizes which can be classified as "miniatures", measuring less than 2" in height in the closed position. They are normally supplied with moulded, black, Nylon handles, but colored handles can be supplied for special identification purposes. Panel mounting lock-nuts are included as standard equipment on every valve.

The second type is the 490 Series, a cam-closing toggle valve for service up to 2000 psi. They'll give you the same quick, positive action as the 450 Series, while performing the toughest laboratory and process jobs. The 490 and the 450 are excellent performers on non-critical high vacuum. They can be helium leak-tested for this purpose.

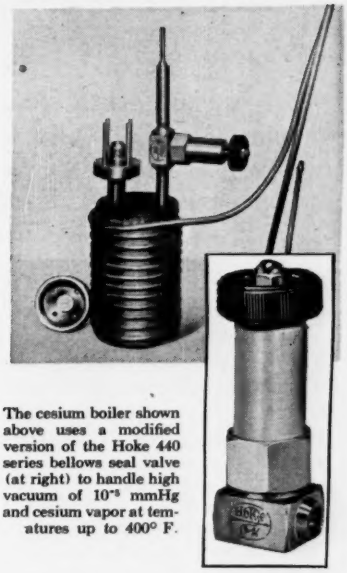
So, if you're interested in switch-action flow control, investigate the Hoke toggle valves. We'll be happy to equip you with complete technical data. A check in the coupon to the right will bring you the facts.

The development of packless valves has so greatly reduced the problems of handling high pressures, temperatures and vacuums, and dangerous fluids that engineers designing such systems can now spend more time curled up with the Hoke Corrosion Chart.*

With this extra time, many have dreamed up weird applications for the Hoke 440 Series bellows seal valve, trying to snare us in our own semantics. In a rash moment, we boasted that this valve could be modified for almost any application. Actually, the 440 can be modified to work at high pressures (up to 2000 psi), for high temperatures (up to 1000°F.), and for special connections such as tubing, socket welding, and silver brazing.

Aside from this horn-blowing, here are the dry facts. The basic design includes a stainless steel body, inert arc-welded bellows assembly, Teflon gaskets and Teflon stem point discs. This is only the starting point. Minor modifications make so many models available that almost any problem, including liquid metal handling, can be solved.

Hear what a disbeliever said: "I did not believe that the modified valves would satisfy all my requirements, especially to keep a high vacuum of the order of 10^{-8} mmHg under a wide variation of temperatures; however, I now acknowledge that the modified Hoke 440 valves fulfilled their duty perfectly." This came from The Martin Company, where we sent 440's for use in cesium vapor up to 400°F. Special



The cesium boiler shown above uses a modified version of the Hoke 440 series bellows seal valve (at right) to handle high vacuum of 10^{-8} mmHg and cesium vapor at tematures up to 400° F.

modifications made these valves readily usable on a cesium boiler and converted an infidel to the true valve.

If you work with critical high vacuum, high pressures, high temperatures and dangerous fluids, proceed with care. Ask for our Packless Valve Bulletin to reap a harvest of engineering plums.

** Makes good reading if you're handling corrosive agents. Write, and we'll send you one.*

FREE! A STEADY FLOW OF FACTS!

Further flow features, and interesting technical topics are carefully covered in Hoke's technical publication, the FLOW SHEET. It's free, but worth millions! To get the full benefit of our engineering and editorial efforts six times a year, mark your "X" in the proper box.

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CIRCLE 66 ON READER-SERVICE CARD

Calibrating Thermocouples

National Bureau of Standards methods for calibration of platinum versus platinum-rhodium, copper-constantan, Chromel-Alumel, and iron-constantan thermocouples are described.

WM. F. ROESER
National Bureau of Standards

COMBINATIONS of metals and alloys used extensively in thermocouples are listed in Table 1, together with the temperature ranges in which they are generally used and the maximum temperatures at which they can be used for short periods. The period of usefulness at high temperatures depends largely on the temperature and the diameter of the wires.

Abstracted from NBS Circular 590, *Methods of Testing Thermocouples and Thermocouple Materials*, by Wm. F. Roeser and S. T. Lonberger.

One of the important applications of the method of calibrating thermocouples at fixed points is found in the calibration of platinum versus platinum-10% rhodium thermocouples to realize the International Temperature scale in the range 630.5° to 1063.0°C. From such a calibration, together with methods of extrapolation, the temperature-emf relationship of this type of thermocouple can be determined with an accuracy of about 2°C at 1,450°C. Calibration at a few other selected points below 630.5°C will yield a working standard

TABLE 1—THERMOCOUPLE MATERIALS, TEMPERATURE RANGES, CALIBRATION POINTS AND ACCURACY.

Type of thermocouple	Methods of calibration	Temperature range	Calibration points	Accuracy at observed points
		°C		°C
Platinum versus platinum-10-percent-rhodium.	International Temperature Scale (fixed points).	630.5 to 1,063.0	Freezing point of Sb, Ag, and Au.	0.2
Platinum versus platinum-rhodium.[a]	Fixed points	0 to 1,450	Freezing point of Zn, Sb, Ag, and Au.	.2
	NBS Standard Samples, fixed points.	0 to 1,450	Freezing point of Sn, Zn, Al, and Cu.	2
	Comparison with standard thermocouple.	0 to 1,450	About every 100° C	.3
	----do	0 to 1,450	About 600° and 1,100° C (or more points).	.3
Chromel-Alumel	Comparison with standard thermocouple.[a]	0 to 1,100	About every 100° C	.5
	----do	0 to 1,100	About 500°, 800°, and 1,100° C (or more points).	.5
	Comparison with standard resistance thermometer [b] or at fixed points.	0 to 350	About every 100° C	1
	Comparison with standard resistance thermometer.[b]	0 to −190	About every 50° C	1
Iron-constantan	Comparison with standard thermocouple.[a]	0 to 760	About every 100° C	.5
	----do	0 to 760	About 100°, 300°, 500°, and 750° C	.5
	Comparison with standard resistance thermometer [b] or at fixed points.	0 to 350	About every 100° C	.1
	Comparison with standard resistance thermometer.[b]	0 to −190	About every 60° C	.1
Copper-constantan	Comparison with standard resistance thermometer [b] or at fixed points.	0 to 300	About every 100° C	.1
	Comparison with standard resistance thermometer.[b]	0 to 100	About 50° and 100° C	.05
	Fixed points	0 to 100	Boiling point of water	.05
	Comparison with standard resistance thermometer.[b]	0 to −190	About every 60° C	.1
	Fixed points	0 to −190	Sublimation point of CO_2 and boiling point of O_2.	.1

[a] Either 10- or 13-percent rhodium. [b] In stirred liquid bath.

that is accurate to a few tenths of a degree in the range 0° to 1,100°C. Fixed points also are used conveniently with various degrees of accuracy ranging from 0.1° to 5°C in the calibration and checking of various types of thermocouples in the range −190°C to the melting point of platinum (1,769°C). The fixed points for which values have been assigned or determined accurately and at which it has been found convenient to calibrate thermocouples are given in Table 2. The values in the table apply for a pressure of 1 standard atmosphere (760 mm of Hg) and the variations of the boiling temperatures with pressure are given in the last column.

Accuracies Obtainable

The accuracies obtained in calibrating the various types of thermocouples by different methods, and the uncertainty in the interpolated values by various methods are given in Table 1.

These accuracies can be obtained with homogeneous thermocouples when reasonable care is exercised. In Chromel-Alumel and Iron-Constantan thermocouples at low temperatures, the accuracy given is limited by the uncertainty in interpolated values. However, this uncertainty can be reduced by observing the emf of the thermocouples at more points. The accuracy obtained with Copper-Constantan thermocouples at low temperatures is usually limited by the emf measurements; in such cases the accuracy can be improved by employing a number of thermocouples in series (multiple-junction couples).

Calibration Services

The following services are provided by the National Bureau of Standards for fees covering the cost.

(1) Thermocouples are calibrated and certified as accurately as the conditions of use and the homogeneity and stability of the wires justify. The accuracies given in Table 1 have been found to meet most needs.

(2) Indicators used with thermocouples are calibrated separately or in combination with a particular thermocouple.

(3) The thermal emf's of thermocouple materials against the standard Pt 27 are determined and the results certified to the limits justified by the material.

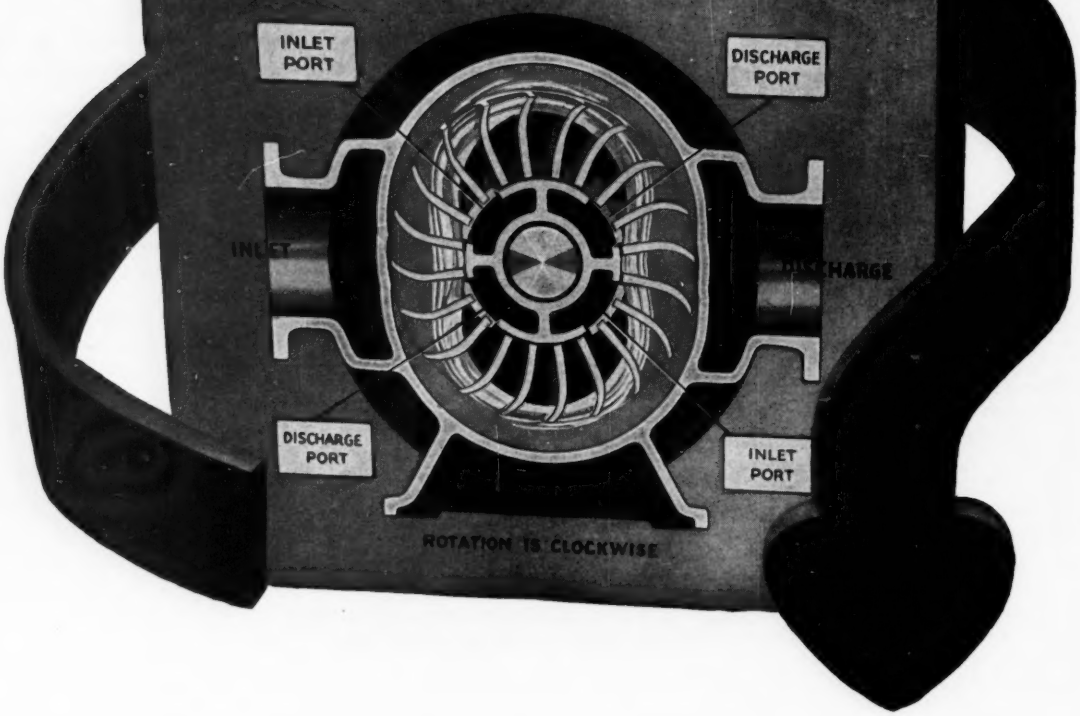
(4) Standard samples of metals are distributed, each with a certificate giving the value of the freezing point. The freezing-point metals being distributed at present are tin, lead, zinc, aluminum, and copper.

TABLE 2—FIXED POINTS AVAILABLE FOR CALIBRATING THERMOCOUPLES.

Thermometric fixed point	Values on the International Temperature Scale of 1948				Temperature of equilibrim (t_p) in degrees C as a function of the pressure (p) between 680 and 780 mm of mercury. p_0 is standard atmospheric pressure.
	Assigned (primary points)		Determined (secondary points)		
	°C	°F	°C	°F	
Boiling point of oxygen	−182.970	−297.346			$t_p=-182.970+9.530\left(\frac{p}{p_0}-1\right)-3.72\left(\frac{p}{p_0}-1\right)^2+2.2\left(\frac{p}{p_0}-1\right)^3$
Sublimation point of carbon dioxide.			−78.5	−109.3	$t_p=-78.5+12.12\left(\frac{p}{p_0}-1\right)-6.4\left(\frac{p}{p_0}-1\right)^2$
Freezing point of mercury			−38.87	−37.97	
Ice point	0	32			
Triple point of water			+0.0100	32.0180	
Boiling point of water	100	212			$t_p=100+28.012\left(\frac{p}{p_0}-1\right)-11.64\left(\frac{p}{p_0}-1\right)^2+7.1\left(\frac{p}{p_0}-1\right)^3$
Triple point of benzoic acid			122.36	252.25	
Boiling point of naphthalene			218.0	424.4	$t_p=218.0+44.4\left(\frac{p}{p_0}-1\right)-19\left(\frac{p}{p_0}-1\right)^2$
Freezing point of tin*			231.9	449.4	
Boiling point of benzophenone			305.9	582.6	$t_p=305.9+48.8\left(\frac{p}{p_0}-1\right)-21\left(\frac{p}{p_0}-1\right)^2$
Freezing point of cadmium			320.9	609.6	
Freezing point of lead*			327.3	621.1	
Freezing point of zinc*			419.5	787.1	
Boiling point of sulfur	444.600	832.280			$t_p=444.600+69.010\left(\frac{p}{p_0}-1\right)-27.48\left(\frac{p}{p_0}-1\right)^2+19.14\left(\frac{p}{p_0}-1\right)^3$
Freezing point of antimony			630.5	1166.9	
Freezing point of aluminum*			660.1	1220.2	
Freezing point of silver	960.8	1761.4			
Freezing point of gold	1063.0	1945.4			
Freezing point of copper*			1083	1981	
Freezing point of palladium			1552	2826	
Freezing point of platinum			1769	3216	

* The values given in this table for these materials are the values stated in the International Temperature Scale of 1948. Standard Samples of these materials are procurable from the National Bureau of Standards with certificates giving the freezing point of the particular lot of metal.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



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You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
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No internal lubrication to contaminate air handled.
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Original performance constant over a long pump life.
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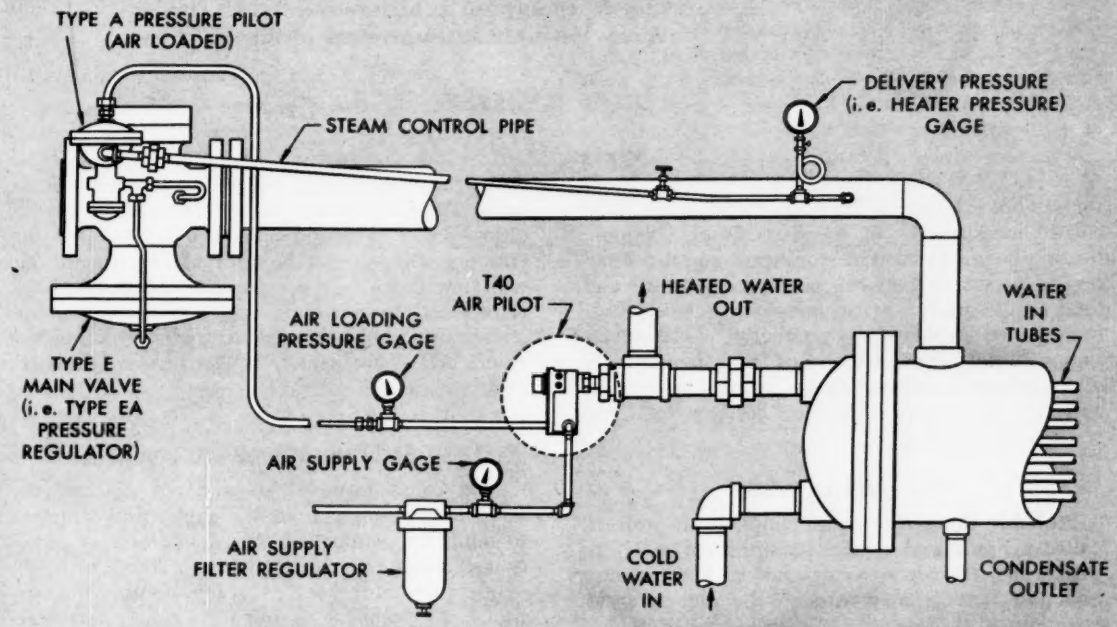
New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs


TYPE A PRESSURE PILOT (AIR LOADED)
STEAM CONTROL PIPE
DELIVERY PRESSURE (i. e. HEATER PRESSURE) GAGE
T40 AIR PILOT
HEATED WATER OUT
WATER IN TUBES
AIR LOADING PRESSURE GAGE
TYPE E MAIN VALVE (i. e. TYPE EA PRESSURE REGULATOR)
AIR SUPPLY GAGE
AIR SUPPLY FILTER REGULATOR
COLD WATER IN
CONDENSATE OUTLET

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

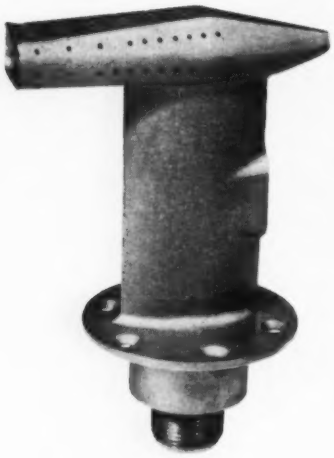
This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York SE-148A

CIRCLE 67 ON READER-SERVICE CARD



TOTAL-TEMPERATURE MEASUREMENT

Total temperature is the temperature measured by a probe that arrests and converts to heat the kinetic energy of a high-velocity gas. This includes the original temperature of the gas at rest.

FRANK D. WERNER, Rosemount Engineering Co.

IN LOW-SPEED flight, below about Mach number 0.3, outside air temperature is not difficult to measure. As air speed increases, frictional heating begins to become significant and a distinction is necessary between static temperature and total temperature.* Static temperature is difficult to measure above Mach number 0.3 and nearly impossible at supersonic speeds; total temperature measurement is relatively easy. Liquids rarely flow so fast as to require distinction between total and static temperatures.

The Diffuser Probe

Probably the earliest total-temperature probe is called a Franz probe, after its author (Fig. 1). In this probe, the air is compressed at the entrance end and flows slowly through the entrance, decelerating still more in a subsonic diffuser, thence passing over the sensing element and out the bleed holes. The bleed holes permit continuous heat addition. Later developments have shown that the entrance diffuser can be omitted because the air will slow down to the same extent if the diffuser is replaced by a simple cavity open on the upstream side. Probes having a diffuser, including the Franz probe, are usually referred to as "diffuser" probes.

Simple Total-Temperature Probes

Next came improved methods of isolating the temperature sensor from the supporting structure to minimize conducting errors, addition of radiation shielding for high total temperatures, selection of the optimum internal Mach number for the probe, development of miniature types, and internal boundary-layer control to separate water droplets and other foreign particles from the air sample and also permit application of de-icing heat.

It was found that a sensing element surrounded by a simple cavity open on the upstream side and short in the streamwise direction constituted a satisfactory and practical type of total-temperature probe (Fig. 2). This type probe is still in wide use in many applications requiring maximum economy, small size, and moderate accuracy. As the structural

*"Total" temperature is sometimes called "stagnation" temperature. Total temperature is static temperature plus the temperature realized when the kinetic energy of the air relative velocity is converted into heat. Static temperature is the temperature of the air at a distance from the airplane. The terms "free air temperature," "ambient temperature," and "outside air temperature" are often ambiguously applied to static, total or an intermediate temperature.

Abstracted from ASME Paper No. 58-AV-17.

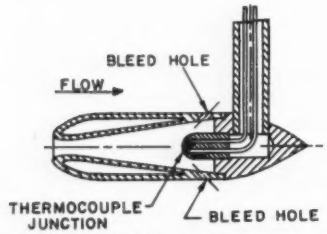


FIG. 1. EARLY total-temperature (Franz) probe measures temperature of air arrested by supersonic flight.

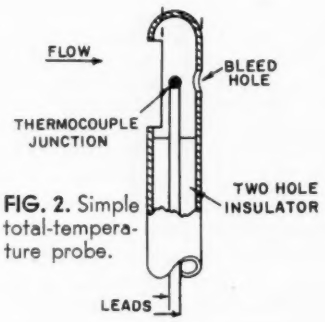


FIG. 2. Simple total-temperature probe.

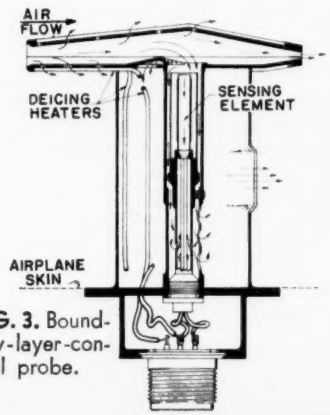


FIG. 3. Boundary-layer-control probe.

parts are ordinarily considerably below the total temperature, conduction errors can occur if heat is conducted from the sensing elements to the supporting parts.

Optimum Internal Mach Number

If the size of the bleed holes is too small there is insufficient heat convection into the probe. If these ports are too large, the Mach number of the flow over the sensing element will not be low, resulting in recovery error. Recovery error is a low reading due to excess cooling of the element by the gas passing through. Determination of an optimum Mach number has been the subject of much analytical and experimental study.

Boundary-Layer-Control Probes

A recent total-temperature probe development is shown in Fig. 3. It controls boundary-layer growth on the interior surfaces. The pressure within the probe is much higher than outside, with the result that boundary-layer air is drawn off via the holes as indicated. Furthermore, the flow is caused to turn a rather abrupt right angle and separation at the turn is prevented by boundary-layer removal at the inside of the turn. This construction prevents water droplets from impinging on the elements and causing errors. Also, it permits the sensing element to be delicate and fast in response while protected from damage by flying sand and the like. Finally, this design permits de-icing heat on the exterior with a negligible effect on the indicated total temperature because the heated boundary-layer air is drawn off.

Sensing Element Types

For flight applications the most common sensing types are thermocouples and resistance thermometers. Among the resistance-thermometer types are those using platinum, nickel, and Balco wire, and those using thermistors. The particular sensing type used has little effect on the basic characteristics, except for speed of response and self-heating effects.

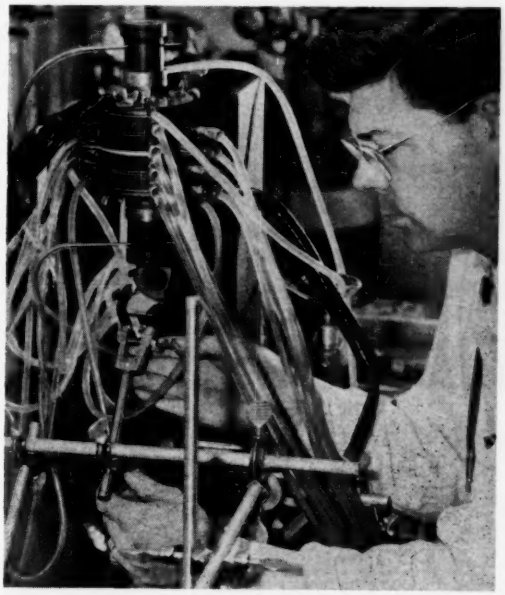
High-Temperature Gas Thermometry

NATIONAL BUREAU OF STANDARDS has been studying electric arc techniques as sources of stable, controlled gas temperatures up to 20,000°K. Also under investigation are spectroscopic methods to measure reliably such high temperatures.

A device for maintaining a controlled electric arc in an atmosphere of any desired composition consists of a stack of water-cooled copper washers alternating with electrically insulating bakelite washers (Fig. 1). The arc burns in the central cylindrical core of this stack of washers between electrodes at each end. The gas to be studied is introduced into the core of the arc. Windows are provided along the sides and at the ends of the apparatus for optical viewing and spectrographic analysis of the radiation from the arc. Research is concerned mainly with comparisons between photoelectric and photographic measurement methods; comparisons between observation from the side and along the arc axis; and with effects of optical geometry, arc length, and current in an effort to determine their importance to the precision and accuracy of temperature measurements.

Obtaining suitable high-intensity light standards for use in measuring absolute intensities of the arc spectroscopic lines is difficult. Therefore, high-temperature continuum radiation standards are being improved. A carbon tube blackbody heated directly by a heavy current has been developed and seems promising as a constant radiation standard up to a temperature of about 3000°K. Also under construction is a very-high-pressure free-burning arc which may provide a suitable standard of continuum radiation corresponding to temperatures of 10,000°K or more.

FIG. 1. CHARLES R. YOKLEY views high-temperature furnace for maintaining a controlled electric arc in an atmosphere of any desired composition. An electric arc burns in the central cylindrical cavity of the stack of washers.



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TEMPERATURE-PROBE

ALVIN B. KAUFMAN
Litton Industries, Inc.

Response time of a temperature probe is one of the most important parameters in temperature measurement and control—yet methods and standards for measuring and classifying temperature-probe response times are difficult to find in the literature. Response nomenclature and meanings are not widely known. Many temperature-probe advertisements specify a response time without clearly stating the medium; some do not even state the percentage of total recovery used for the response specified.

Response tests are usually based on water media, either agitated or static. Often this response data correlates closely enough to other fluid media, such as hydraulic oil and alcohol, to be directly usable. However, highest accuracy measurements involve the response of the transducer and the specific heat and thermal conductivities of the probe materials and surrounding media.

The author proposes, as an industry standard, to rate transducer response time (seconds or milliseconds) in terms of 63% and 90% recovery of a step-function temperature change for three liquid media —(1) static water, (2) liquid argon, and (3) ambient air to liquid argon. Gas-media probes should be rated similarly for (1) static and (2) dynamic air conditions.

TRANSDUCER RESPONSE can be specified in terms of response rate, but response rating in degrees/second is an impractical and poor method of expressing response. For example, if a probe requires one second for 90% recovery of a 100F° step change in temperature, its response *rate* will be 90°/second; if exposed to a 1000F° step function, the response rate is 900°/second. The same probe thus has different responses in "degrees/second," and this term has meaning only when the step change is specified. When step-function span is not specified, the probe response rating is valueless and can lead to erroneous conclusions when comparing temperature probes.

However, response time rating in terms of *time to traverse a given percentage* of a step function is a constant, regardless of the magnitude of the temperature step-function. The *rate* (degrees/second) will vary with the magnitude of the step change, but the *time* for a 63% or 90% change remains constant, just as an electric capacitor has one time constant to charge up through a resistor to any given percentage of a step change in applied voltage ($t = RC$, independent of applied voltage).

Response Factors

Measurements involving heat transfer between materials involve three parameters—thermal conductivity, specific heat, and thermal capacity.

Thermal conductivity is a measure of the time rate of transfer of heat by conduction through a material. It can be expressed as the quantity of heat in calories which is transmitted per second through a plate one centimeter thick and one square centimeter in area, when the temperature difference is one degree centigrade. This is a *rate* figure with a stabilized temperature differential; it does not imply or describe response to a step input. The thermal conductivities for many materials encountered by the instrumentation engineer are presented in Table 1.[1,3]

Thermal capacity is the number of calories required to raise the temperature of one gram of a material one centigrade degree.

Specific heat is the ratio of the thermal capacity of a material to the thermal capacity of air-free water at 15°C and 1 atmosphere pressure.

RESPONSE TIME

FIG. 1. TEST ENGINEER about to determine the water response time of an immersion temperature transducer. Event marker (length of TV-antenna lead-in wire with ends stripped) is taped to probe.

Probe Design Factors

A "fast" probe (one having short response time) should be made of materials that have high thermal conductivity (for good heat transfer) and low specific heat (small thermal capacity). However, a major problem in probe design as well as use is the fact that materials having high thermal conductivity generally have high specific heat.

The response of a temperature probe in a medium depends on the thermal conductivity of the medium. However, its response in another medium generally cannot be predicted simply by the ratio of thermal conductivities between that of the test medium and the operational medium. Some probes are relatively unaffected by the conductivity of the medium; this is particularly true for most enclosed temperature-sensitive resistive elements. However, where a bare wire or film element is supported only at its ends (surrounded elsewhere only by air), a relationship can be found between response time and medium conductivity. Further, the specific heat as well as the conductivity of the medium influences response; therefore, temperature probe response presupposes a specific surrounding or surface medium and cannot be stated as that of the probe alone. Response data thus should include the medium used to obtain the response.

Response Measurements

Two media are required for response measurements, each at a different but stable temperature. The initial (staging) medium establishes the probe's initial temperature; the other (response) medium, imposes the step change. The staging temperature and medium is unimportant, except for precautions noted later. Further, the temperature of the staging and response media need not be known. The response of the probe to the step change in temperature is simply recorded, and the time required for 63% and 90% of the total response is measured. These are the time constants of response for the response medium used.

One of the easiest media to obtain and use successfully is water. However, the temperature transducer must be waterproof or of low enough resistance (1K ohms or less) that distilled water does not affect the readout resistance to an appreciable extent. Distilled water has fairly low conductivity;

TABLE 1—THERMAL CONDUCTIVITY OF VARIOUS SOLIDS, GASSES, AND LIQUIDS

Media	Thermal Conductivity*
Air	0.000057
Argon	0.000039
CO_2	0.000031
Ammonia Gas	0.000046
CO	0.000050
Helium	0.000339
Hydrogen	0.000327
Methane	0.000065
Nitrogen	0.000052
Oxygen	0.000056
Water	0.00143
Petroleum Oil	0.00035
Methyl Alcohol	0.000495
Mercury	0.0197
Aluminum	0.504
Brass	0.230
Copper	0.918
Steel	0.111
Nickel	0.142

*Cal/sec through cubic cm at 1C° temperature differential.

TABLE 2—COMMON REFERENCE TEMPERATURES*

Boiling Water	212°F
Ice Water	32°F
Liquid Oxygen	—297.35°F
Liquid Argon	—302.25°F
Liquid Nitrogen	—320.45°F
Liquid Hydrogen	—422.9°F
Liquid Helium	—452°F

*The accuracy of these temperatures depends on air pressure. See references.

what conduction does occur is due to ionizable elements. Tap water can be used where the transducer is waterproof.

Ice water has an equilibrium temperature[2] of 32°F. Introducing a warm transducer into ice water will not change the medium temperature because of the ice. Where an ice bath is not used, however, it is important to have sufficient quantity of fluid medium to prevent the transducer itself from changing the temperature of the medium.

Measurement Technique

The transducer is connected to a suitable measurement system, bridge or potentiometer, which produces an output potential. The output is connected to a graphic recording device with a sine-wave frequency response at least 10 times faster than the shortest response-time expected. If a bridge is used, the bridge excitation is set so that it does not exceed the power or current rating of the temperature transducer. The recording system gain is adjusted to accept the bridge signal output span without amplifier saturation or hitting stops (depending on instrument used). The resistance of the transducer—if known or determined before hand for the medium used—can be introduced via a resistance decade box for system setup.

With the system set up for recording, the temperature transducer is allowed to stabilize in room air. Sufficient time (generally 2 to 30 minutes) is allowed for stabilization—until little or no output signal drift is noted. A draft shielding box is sometimes required over the transducer. The recorder then is set for adequate paper speed and the drive motor activated.

The transducer then is plunged into the ice bath, usually consisting of an open-mouth Dewar (thermos) flask liberally filled with crushed or shaved ice and water (Fig. 1).

The resulting record (Fig. 2) then is used to determine the *water response time*. The span between the two stabilized and parallel deflection positions equals 100% response; 63% of this deflection from the starting position is determined and marked on the trace. Using the time marker lines on the record (or an auxiliary pen recording of a known frequency), the time from the first record deflection to the 63% point on the curve is determined. This time is the 63% response. A similar procedure is used to determine the 90% response time. As the response is usually not a perfect exponential, the 90% response will not always be 2.3 times the 63% response. Hence both 63% and 90% response times should be given.

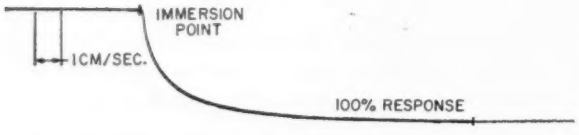

FIG. 2. TYPICAL TRANSDUCER response in 32°F water bath.

Several precautions must be observed. The first deflection may not indicate the exact time of immersion, the start of the response-time measurement. A heavy-walled, insulated, or large-thermal-mass probe may not begin to indicate a response until several seconds after its immersion. Thus to secure accurate time data a response *event marker* is desirable. This will mark the trace at the immersion point (Fig. 2).

The marker comprises a pair of insulated wires attached to the probe so that a stylus or recording pen can be energized at the moment of immersion by the water conductivity between leads. A suitable event marker circuit is shown in Fig. 3. The relay response and instrument system delay is a minor factor for slow-response transducers. Fast-response transducers generally do not require event marking of this type.

It is important that the initial (staging) temperature established in the transducer be below the boiling point of the response medium (water in this case). If it is not it can cause the response medium to boil, and a gaseous interface will be formed on the transducer. Accurate response data cannot be secured under these conditions. Also, a high initial temperature can cause a rise of temperature in the second medium, thus invalidating the data.

One should never start with a liquid medium and move the probe into air for air response. Some liquid may remain on the probe and its specific heat, thermal conductivity and evaporation from the probe will radically affect the response data so that a true response is not obtained.

Response in liquefied gasses (oxygen, helium, nitrogen, argon, etc.) requires techniques somewhat different than that for materials normally liquid at room temperature. If a "warm" (room-temperature) transducer is placed in a liquefied gas, the liquid "boils" at the surface of the transducer. This interface thermal barrier reduces thermal conductivity and lengthens measured response time. Fig. 4 shows this for a platinum element probe. The graph reveals the point when interface outgassing ceased

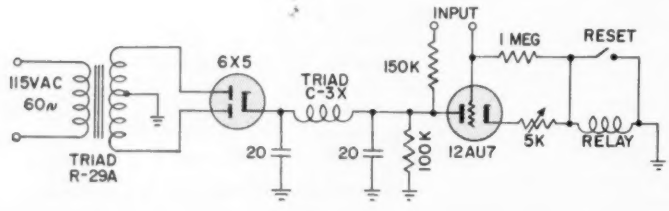

FIG. 3. SCHEMATIC OF event marker. Relay contact output permits versatile application. (Note: Relay solenoid is shown, but not its contact. The reset switch is not the solenoid contact.)

and liquid contacted the stem element, with a resultant rapid increase of response. Therefore, in liquefied-gas response-time measurement, two media at approximately the same temperatures are used. One common medium is liquid oxygen (LOX).

LOX Response Measurement Technique

The Dewar flasks are placed side by side. One is charged with LOX (−297°F), the other with liquid argon (−302°F) The test probe is immersed in the argon until all signs of gassing (boiling and bubbling) at the probe have ceased and transducer resistance stabilizes. The probe then is transferred rapidly to the LOX. Note that the pre-cooled transducer is transferred to a warmer liquid; hence little or no gassing will occur to interfere with an accurate response measurement.

Thermistor temperature elements used at LOX temperatures do not exhibit any change of resistance in the resistance range used until temperatures below −250°F are encountered. Thus any response curve made with an initial air medium will show a time period in which no action occurs. The usable temperature range of the transducer should be considered when selecting media and determining response.

Air Response

Static air response measurement requires simple equipment—two cardboard boxes. Some dry ice is dropped into one. The transducer is suspended above the dry ice and the opening covered with a cloth. After stabilization has occurred, the transducer is removed rapidly and placed in the second box, which is also covered with a cloth. The transducer must not touch the sides of the containers or have ice or liquid condensation on its surface. Such a simple response test is adequate only with transducers having a 63% recovery in 10 seconds or longer.

Static air response runs are generally long, and a stable response medium is required; thus the final static-air medium should be at ambient temperature, which is stable for at least 4 or 5 minutes, adequate for the test. Of course, many alternatives are possible, such as using a chamber cooled by an ice bath.

Dynamic air response must be predicated on a particular air flow velocity; CFM or mass flow ratings are not satisfactory because air velocity is a function of the area of the delivery or test aperture. The air density and its velocity past the transducer establish the thermal relationship. Hence a suitable industry standard should specify both air velocity and density. It is proposed, therefore, that a velocity of 2750 fpm (approximately 30 mph) at a nominal sea-level air density of 760 mm Hg at 60-90°F be used. Variation of air density throughout the United States has a negligible effect on the response measurement. The velocity chosen is compatible with that obtained from many electronic-cooling-equipment blowers, and represents a reasonable compromise for an industry standard. Other velocities may be desirable for high-Mach transducers, but equipment for this measurement is difficult to obtain and expensive.

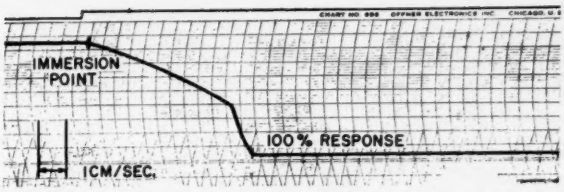

FIG. 4. RESPONSE of a temperature transducer is delayed due to interface gas media. Knee in curve shows where "boiling" ceased and liquid made contact with probe.

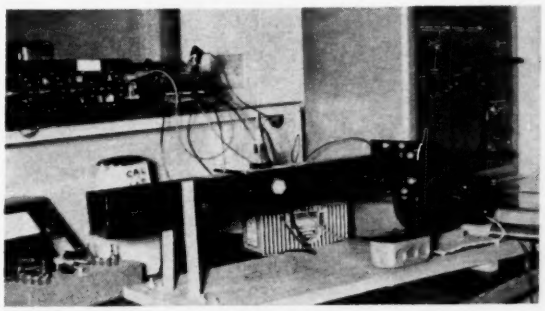

FIG. 5. DYNAMIC AIR response test fixture. A conventional electronic cooling blower is used to supply the required air velocity of 2750 fpm.

Fig. 5 shows a typical dynamic air-response fixture. The transducer is installed in a straight length of pipe at least four diameters from the blower and the end of the duct. Shutter valves on each side of the transducer and an access door allow pre-cooling of the temperature transducer by dry ice. After stabilization, the dry ice is dumped and the access door closed. The shutter valves are opened and the blower allowed to pass air at room temperature over or through the transducer. Data analysis is made as indicated previously.

It is hoped that this article will stimulate the development of commercial equipment for response measurement, and lead to an industry-approved standard of response measurement.

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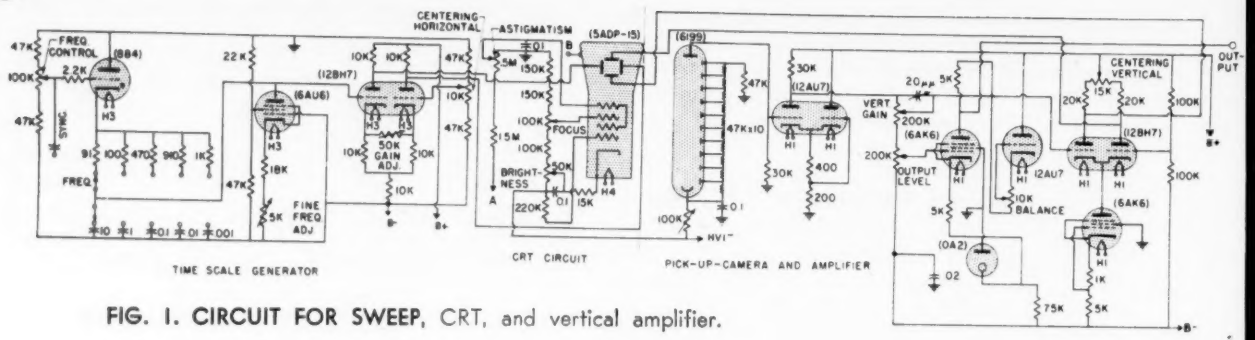


FIG. 1. CIRCUIT FOR SWEEP, CRT, and vertical amplifier.

YUJIRO YAMAMOTO
University of California

C-R Arbitrary-Function

THERE are many applications for an apparatus which generates an arbitrary function—that is, a voltage or current which is some arbitrary function of time or another voltage. The cathode-ray-tube function generator, or *photo-former,* has the high-frequency response for fulfilling the requirement of fast time scales and a wide range of frequencies.

The cathode-ray-tube-type function generator consists of a cathode-ray tube, a photomultiplier, a d-c amplifier, and a horizontal voltage source which is a function of some factor. The block diagram is illustrated in Fig. 2.

Principle of operation of the cathode-ray-tube function generator is as follows: the beam spot is initially adjusted to be centered near the top of the screen; then voltage from the light-voltage converting system (photomultiplier) due to the brightness of the beam spot on the screen goes through the following d-c amplifier, and comes out as output voltage. This output voltage is fed back to the cathode-ray-tube vertical plates, and tends to force the electron beam downwards to the mask, which is cut in the shape of a specified function and attached to the screen of the cathode-ray tube. However, as soon as the spot goes behind the mask, the voltage from the d-c amplifier is phased so that the beam is forced *upward* towards the edge of the mask. This feedback loop keeps the spot on the edge of the mask if the gain of the loop is sufficiently great.

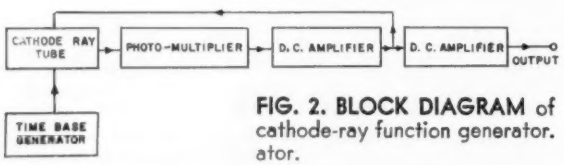


FIG. 2. BLOCK DIAGRAM of cathode-ray function generator. ator.

Ordinarily the deflection sensitivity of the cathode-ray tube is approximately independent of the beam position, and the beam position on the screen is a linear function of the deflection plate voltage. Therefore, after the beam spot reaches equilibrium by the feedback loop, the output voltage is proportional to spot height, which is determined by the mask. Furthermore, since the beam is deflected in the horizontal direction by the voltage which is applied to the horizontal plates, the beam spot moves along the mask-boundary and the output voltage is proportional to the desired function.

Functions with frequency components above 300,000 cps can be generated by this method with an accuracy of the order of 1%, using proper amplifiers. A rise time of 2 microseconds or less can be achieved by employing the best of present day tubes and circuit refinements.

The circuit diagram designed is shown in Fig. 1.

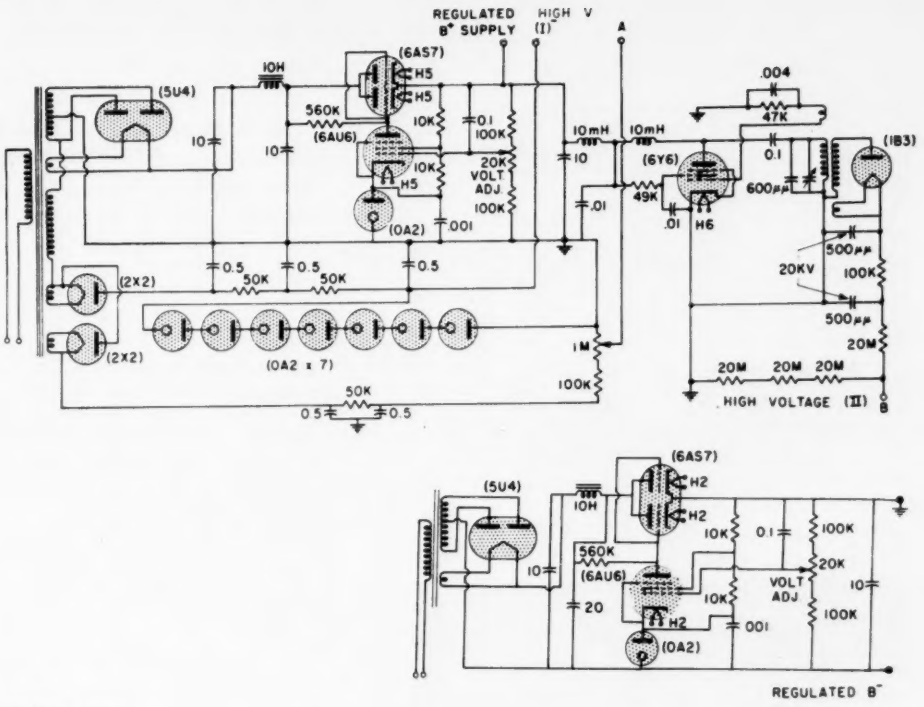


FIG. 3. POWER SUPPLIES. Top shows positive plate supply and negative supply for photomultiplier; bottom shows neagative bias supply.

Generator

Time Scale Generator

A sawtooth wave generator is employed to generate a linear time variable for the x axis (sweep) on the screen. (This section could be replaced with any x-axis parameter generator.)

The x-axis sweep signal is developed by first charging the capacitor (through an 884 thyratron) and then discharging it through a pentode (6AU6). The current through a pentode is determined by the bias and screen potential and is relatively *insensitive* to the plate potential (when operated above the knee of the plate current and voltage characteristic curve)—that is, the pentode is a constant-current device. Discharging the capacitor through a constant-current device produces a linear (rather than exponential) sweep.

C-R Circuit and Pattern Reproduction

The smallest possible beam spot should be maintained on the screen in order to obtain good resolution of a pattern, and the persistence of the screen must be much shorter than the rise time of the system. A flat-surface tube is preferred. The cathode-ray tube (Dumont 5ADP-15) and photomultiplier (type 6199) must be shielded from stray magnetic fields.

The returning period of the sweep voltage must be sufficiently short that a high-frequency-inversed pattern is not produced successively to every main pattern. (One can avoid this trouble by applying the beam-spot blanking technique as used in television receivers.) It is desirable that the sweep generator synchronizes or is synchronized by an instrument which coordinates with the function generator; this may also avoid discontinuity problem between patterns.

Vertical Amplifier

As a d-c amplifer is used for wide response to zero frequency, drift is a problem. As a 20% change in heater voltage corresponds to about 0.2 volt input at the grid of the stage for a tube which has an oxide-coated unipotential cathode, a heater-voltage-effect cancellation circuit (Miller compensation circuit*) was used in the first stage of 12AU7 vertical amplifier. Resistor drift can be minimized by using metalized or special wire-wound resistors of known quality. All resistors should be operated much below their power rating in order to reduce heating effect on resistance values. This effect is usually more pronounced with higher values of resistance than with lower values.

A linear frequency attenuator is recommended for response compensation of the coupling network to the output (Fig. 4). A technique is to use a semi-vari-

**Radiotron Designer's Handbook*, RCA, p. 533, Fig. 12.51A.

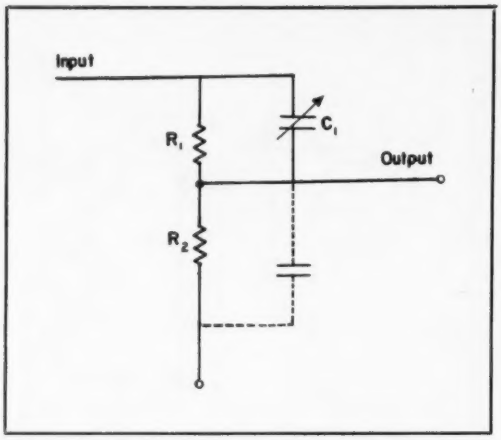


FIG. 4. RESPONSE compensation in resistance coupling network.

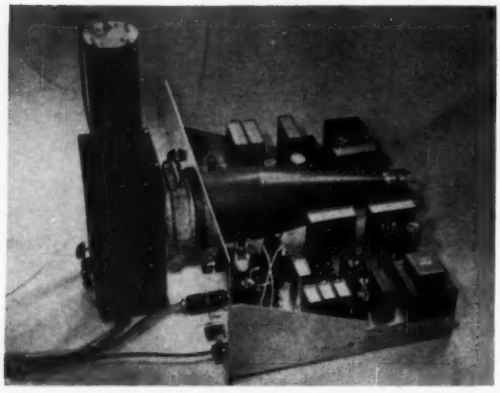


FIG. 5. THE FUNCTION generator, case removed.

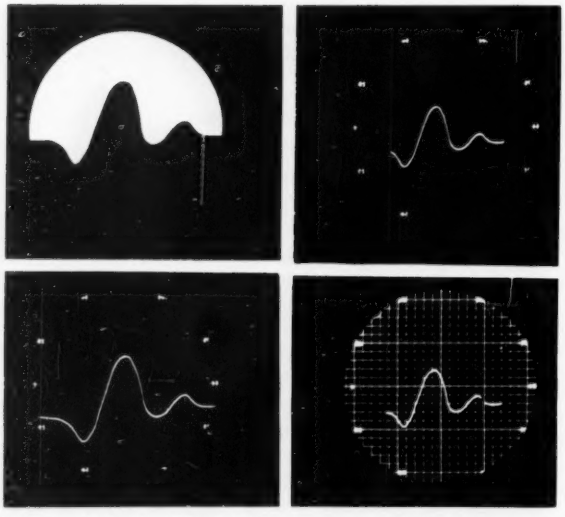


FIG. 6. AN ARBITRARY function generated at recurrent frequency of 3000, 100 and 0.5 cps.

able capacitor for C_1 and adjust it by observing output waveform corresponding to input square wave input.

Zero Point Approach Method of D-C Amplifier Design

Each stage of the d-c amplifier can be treated as an independent circuit by applying "zero-point approach." Some points (grids and plates) can be designed to be zero voltage level. This method may be referred to as zero-point approach. It is useful in constructing a d-c amplifier because each stage can be constructed between zero point to zero point and connected after test. The more complicated the circuit, the more useful is this approach.

Power Supplies

Both the positive plate supply (Fig. 3) and the bias-negative supply are regulated to minimize drift. The negative power supply for the photomultiplier (HV1) is also regulated because the photomultiplier sensitivity varies exponentially with the supplied plate voltage.

Commercial Oscilloscope

It is possible to modify a commercially available oscilloscope to serve as a function generator providing the oscilloscope has adequate frequency range, particularly a low-frequency response. One must supply a light-voltage conversion system (photomultiplier tube circuit) and an output stage which isolates the output load.

Result

The constructed function generator is shown in Fig. 5. A typical waveform of an arbitrary function is shown in Fig. 6. The electron beam spot was traced from right to left.

When a square waveform is generated by this function generator, the rise and fall times are each approximately 8 microseconds, and the output voltage across a 10,000-ohm resistance load is 10 volts per inch of vertical variation of the mask. It is recommended that an optical system be used for coupling between the cathode-ray-tube and the photomultiplier surface.

Output: Arbitrary function; 10 volts per inch of vertical variation of mask (across 10,000-ohm load).

Frequency response: Band width of 0 to 300,000 cps. Rise time of 8 microseconds is achieved.

Sweep frequency: From 2 sec to 0.3 ms per sweep with components shown.

Screen size: 5 inches (use center 4 inches for linearity).

B Supply: 270 v regulated

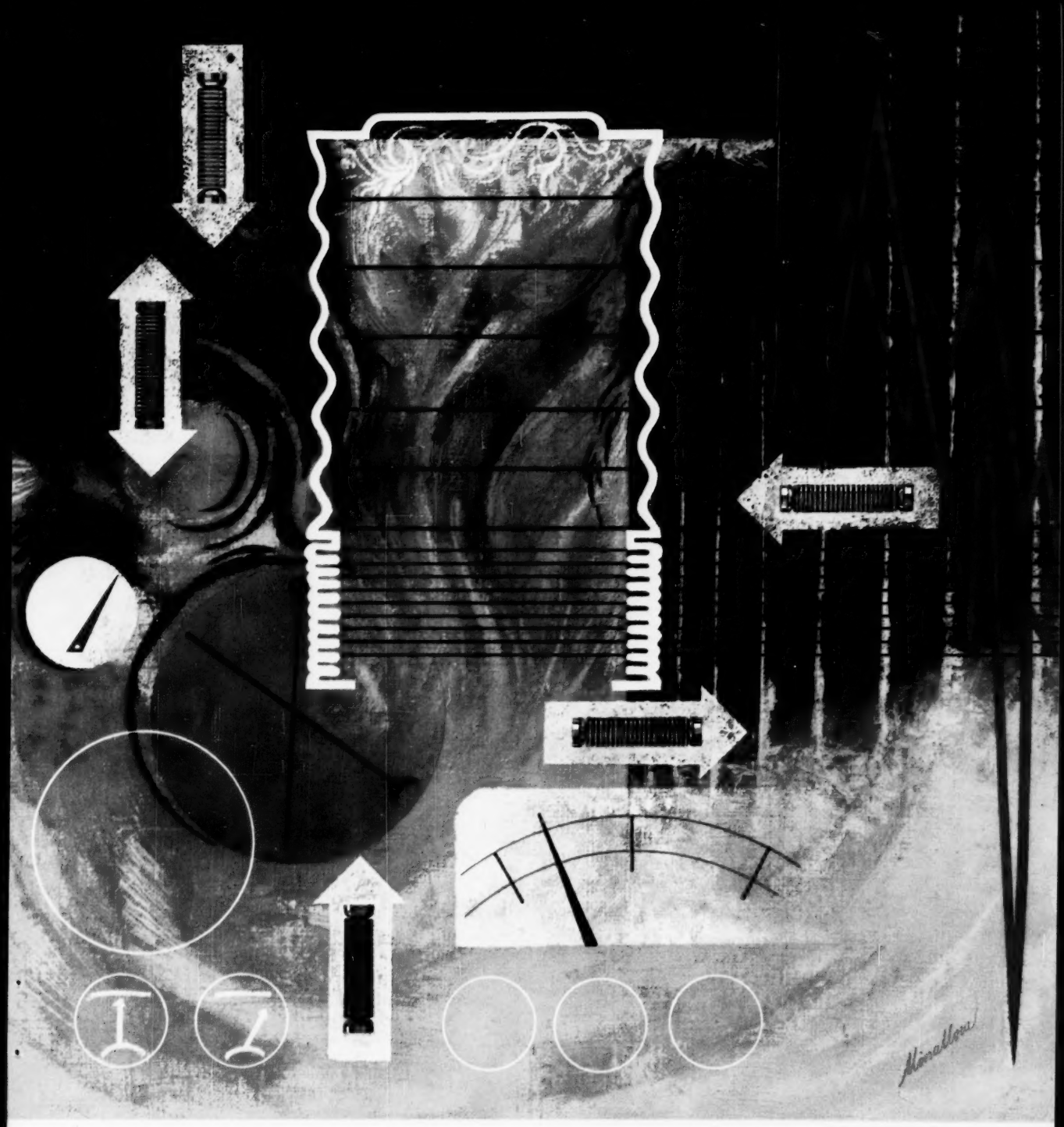
High-voltage supply I: —1050 v regulated

High-voltage supply II: 3000 v unregulated

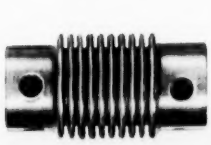
Acknowledgement

The author expresses his appreciation to Professors W. D. Hershberger and E. F. King and Mr. John Dinning for their kind advice and assistance.

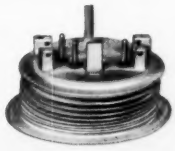
CIRCLE 72 ON READER-SERVICE CARD ⟶



Robertshaw products that spawn new control ideas—Today's most advanced line of metallic bellows, "packaged" metallic bellows and related products . . . made by Robertshaw's Bridgeport Thermostat Division . . . offer engineers new ways to simplify designs, save space and weight, and create higher performance and reliability standards in instrument and control systems.

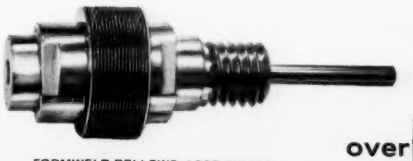


FLEXIBLE COUPLINGS



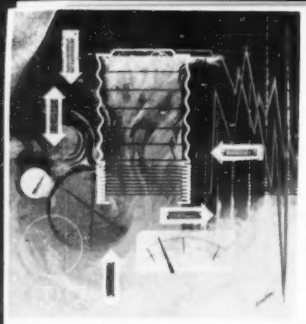
FORMSET BELLOWS

MINIATURE FORMFLEX BELLOWS



FORMWELD BELLOWS ASSEMBLIES

over



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RELIABLE PRODUCTS FOR INSTRUMENTS AND CONTROLS

Ultrasensitive Robertshaw FORMWELD® BELLOWS

for premium performance!

The ultimate in bellows reliability! Robertshaw Formweld Bellows are welded of any suitable alloy to give you the exact properties and characteristics you require. Resistance to temperatures above 1000°F., pressures to 3000 psia plus, and extreme vibration and corrosion conditions. Far more accurate because a precision welding technique perfected by Bridgeport assures closer control of effective area. And FORMWELD Bellows give you more flexibility per thickness of material, lower hysteresis, much greater load capacity without deformation, and lower spring rates. Bellows sizes from ½" O.D. to several inches O.D. Complete assemblies designed, produced, tested and delivered for peak performance.

Write for Bulletin 70.

Robertshaw MINIATURE FORMFLEX* BELLOWS

answer new miniaturization needs!

For the first time . . . hydraulically formed metallic bellows as small as ⅛" O.D. for further miniaturization in instruments, aircraft, missiles and other applications. Also available in ¼" and 3/16" O.D. sizes. Seamless construction for long, leak-free life. All units *custom*-engineered. Complete "packaged" bellows, when produced by Robertshaw, assure maximum performance standards.

*Registration pending

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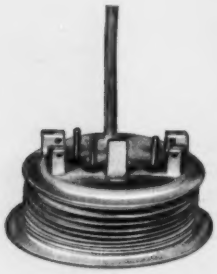
Robertshaw FORMSET® BELLOWS



save up to 90% in bellows length!

Robertshaw FORMSET Bellows are low spring rate seamless metallic bellows with a large stroke per unit of length. Ideal as fluid or gas expansion capsules because of their low spring rate and reduced size. Now used in airborne gyroscopes to handle thermal expansion of the oil which encases the gyroscope. Available in a wide range of bellows metals and sizes . . . *custom*-engineered to your exact needs.

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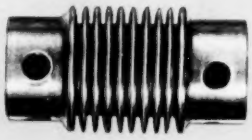
Robertshaw FLEXIBLE COUPLINGS



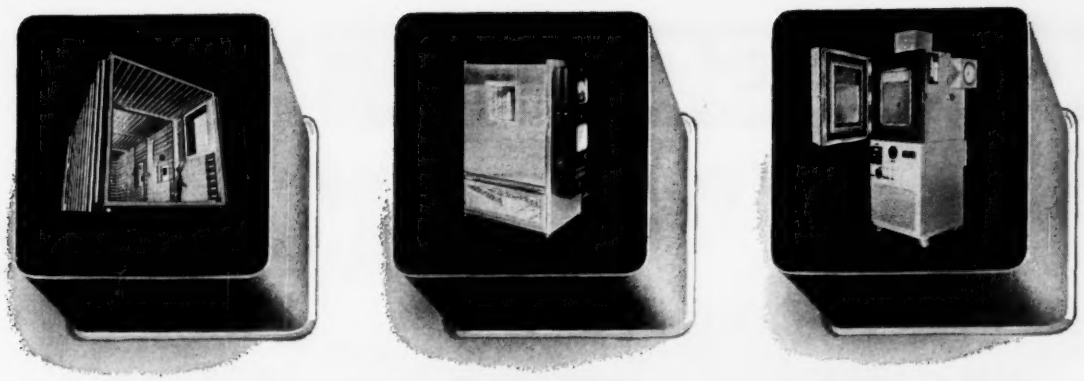
solve backlash, misalignment problems!

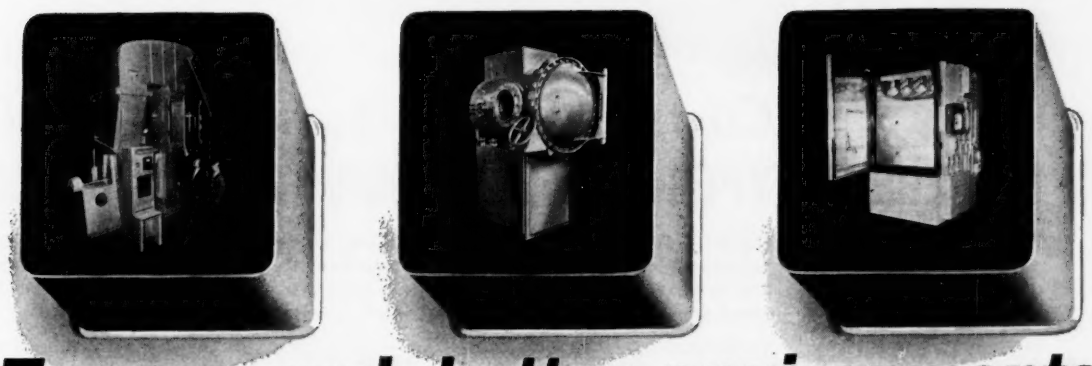
Guard against misalignment friction, bearing wear, backlash and end-play with these small, rugged couplings. Absorb shock and vibration with maximum space and weight savings. Simplify your designs for servomechanisms, instruments and similar drive and control systems. The answer to all these troublesome conditions is the Robertshaw Flexible Coupling, utilizing a seamless metallic bellows connected to two hubs. Several bellows metals and hub designs available. Stock sizes accommodate shafts from ⅛" to ½". Other sizes *custom*-engineered to your needs.

Write for Data Sheet 80.

Robertshaw® MR. CONTROLS

BRIDGEPORT
THERMOSTAT DIVISION
Robertshaw-Fulton Controls Company
Milford, Conn.





Tenney push-button environments

. . . any size, any shape, anytime!

No matter what environmental test chamber you need, this much is certain: Tenney either has it in stock or can adapt one of its proven prototypes. From chambers that could house a family of four, down to refrigerator size (and everything in between), you're sure to find the modern, push-button unit you need.

Altitude, temperature, humidity, explosion, sand, dust, fog—just about every punch nature can throw—can be simulated, either alone or in combination. And you get accurate simulation, complete control and precise measurements every time.

For a complete catalog, describing the entire line, write today to Tenney—the world's largest, most experienced creator of environmental test equipment.

Ask about Tenney's research and development, engineering consultation and design services.

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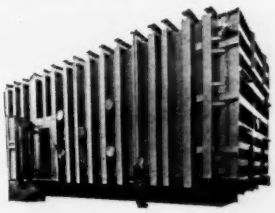


1090 SPRINGFIELD ROAD, UNION, N. J. • PLANTS: UNION, N. J. AND BALTIMORE, MD.

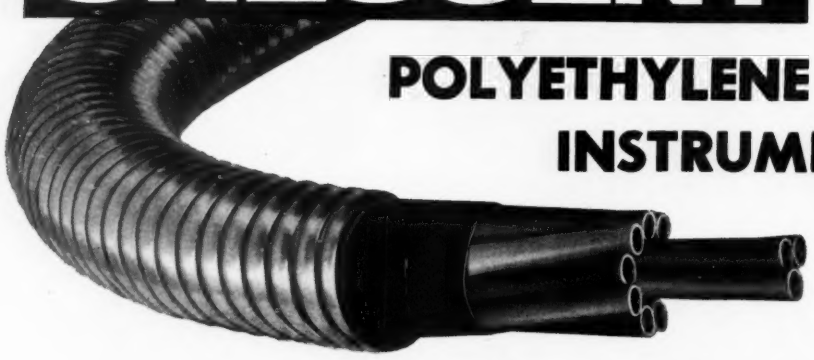
OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT

CIRCLE 71 ON READER-SERVICE CARD

← CIRCLE 72 ON READER-SERVICE CARD

CRESCENT

POLYETHYLENE INSTRUMENT TUBING



Costs Less — is Easier to Install

SIX DIFFERENT TYPES TO MEET YOUR SPECIFIC NEEDS

CRESCENT POLYETHYLENE MULTITUBE is 2 to 37 precision Polyethylene tubes *spirally cabled* together for greatest flexibility. The tubing assembly is protected against mechanical injury by an interlocked galvanized steel armor, Polyvinyl Chloride sheath, or other sheaths, as below.

TYPE P is manufactured from the best high molecular weight virgin Polyethylene compound and TYPE XP of high modulus virgin Polyethylene compound selected for their superior resistance to environmental stress cracking and aging. Extensive research, improved manufacturing methods and rigid test standards have developed CRESCENT Polyethylene tubing to its present level of highest quality. It is furnished as single tubing in ¼", ⅜" and ½" sizes in up to eight bright colors. It is used exclusively in manufacturing CRESCENT POLYETHYLENE MULTITUBE in types as follows:

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

SPECIAL SERVICE TYPES

TYPE XPT-U—Extra heavy PVC sheath over high modulus TYPE XP tubing permits direct burial, or use above ground where subject to moderate abuse.

TYPE XPT-F—Same as XPT-U with heavy asbestos braid and outer PVC sheath. Provides time delay in event of flash fire.

TYPE XPT-FA—Same as XPT-U with heavy asbestos braid and interlocked metallic armor. Provides complete mechanical protection, as well as time delay in event of flash fire.

Write for complete information on these types, as well as types employing copper or aluminum tubing. Ask for Bulletin No. 458-A

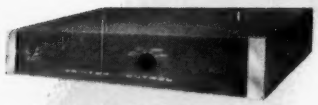
CRESCENT INSULATED WIRE & CABLE CO., INC., TRENTON, N. J.

CIRCLE 70 ON READER-SERVICE CARD

LIKE **WORDS** IN A SENTENCE...

CUBIC DIGITAL SYSTEMS

SPEAK FOR THEMSELVES!



Data Recording

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Voltage Ratio Measurement

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Standard-size Cubic Digital Instruments, with modular construction of plug-in units, make for easy development of sophisticated digital systems from standard off-the-shelf instruments. Wiring of systems is between *cases*, and the release of front-panel locking knobs permits the unit to slide out. Simple or complex systems for measurement and recording are quickly, easily available from Cubic, offering "digital systems that design themselves."

And, of course, Cubic quality speaks for itself, too, with such unique features as "controlled drive" stepping switches which swing up and out for ease of routine maintenance. From front panel to rear connector panel, Cubic's is *the superior* digital instrument.

NEW FROM CUBIC . . . the Talking Meter, instrumentation that really *does* speak for itself, with measurements or other parameters reported to the ear by a clear human voice.

Years-ahead engineering, factory production techniques inspired by pride in the end result, careful quality control and reliability testing . . . all these factors make Cubic's the truly fine instrumentation . . . Digital Systems that speak for themselves.

INDUSTRIAL DIVISION

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Electronic Engineering With a Dimension for the Future

AC Voltage Measurement

DC Voltage Measurement

CIRCLE 73 ON READER-SERVICE CARD

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

CAM-CONTROLLED AIR REGULATOR PROVIDES CONSTANT NIP PRESSURE FOR BUNDLING FABRIC ON ROLL

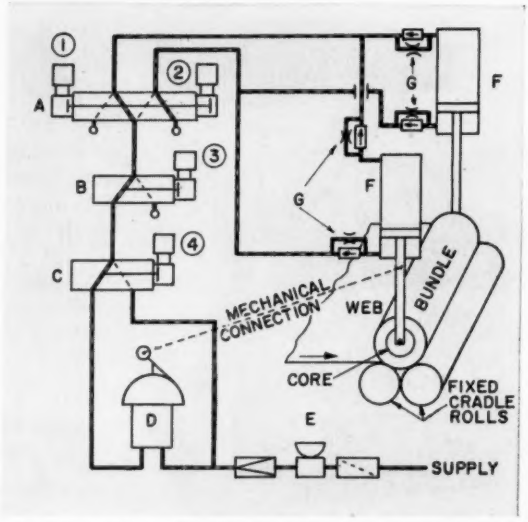
To provide constant nip pressure on a double-drum surface winder a pneumatic-cylinder arrangement is used which furnishes an automatic adjustment of height and pressure.

When a bundle of material (regardless whether it is fabric in a textile mill, or screen webbing of plastic or metal, or the like) is wound on a core, it increases in weight and diameter, so that the downward force increases by the bundle's own weight. To keep this force constant, two double-acting air cylinders (F) are used. They are equipped with 2 check and choke valves (G) each of which provides a time delay for safety.

Heart of the control is a "Type H-3 Controlair" regulator valve (D) which is operated by a circular cam linked by sprockets and chain directly to the core carriage, and thus to the weight of the bundle. The output pressure of the Controlair valve (D) is proportional to the position of the cam. The cam is cut to provide the greatest downward force and nip pressure at the start of the wind-up. At this point solenoid No. 1 of valve A is automatically energized by relays and the air reaches the upper air chambers as shown.

As the bundle increases in weight, the pressure in the upper part of the double-acting cylinder is reduced by action of the rotating cam, and the pressure on the fixed cradle rolls is kept constant.

At a predetermined bundle diameter, the weight of the bundle and core alone is sufficient to exert the required nip pressure. At this point the cam has reduced the pressure output of valve D to zero. A limit switch operated by the cam now deenergizes solenoid No. 1, and solenoid No. 2 is energized to shift valve A. Thus supply pressure is directed by valve D to the lower air chamber of the air cylinder, whereby the force exerted on the bundle is decreased.



This process continues with the growth of the bundle until all pressure in the top chamber is exhausted by Valve B, at which point the bundle reaches its maximum diameter. The bundle now can be de-chucked and removed.

At any time during the operation, manual control can be exercised by pushbutton E to operate valve C, bypassing cam-controlled valve D.

Source: Product Application Memo 96, Westinghouse Air Brake Co., Wilmerding, Penna.

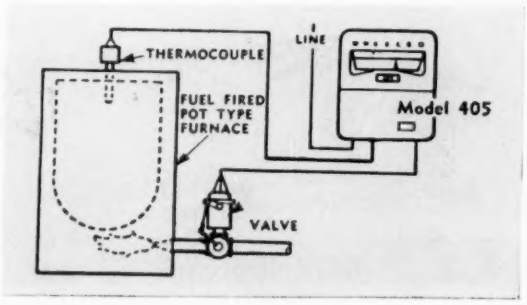
MELTING FURNACE USES PROPORTIONAL POSITION CONTROL FOR FUEL FEED

A simple electric control which proportions the fuel input to the heat required for melting in a pot-type furnace is achieved by an electronic bridge-type indicating controller. This proportional position controller, Model 405, incorporates a polarized relay which receives its signal from a thermocouple sensing the temperature in the melt. A change in temperature will produce an unbalance in the control circuit and the "Micropositioner" relay, which serves as a pilot for the electric valve actuator, will rebalance the bridge by moving the valve actuator in the direction to restore the temperature toward the set point.

Circuit has fine record of success.

Equipment used: Proportional Position Controller, Capacitrol Model 405; Valve actuator, Barber-Colman, Wheelco.

Source: Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.; also "Wheelco Comments," Vol. 14, No. 6.



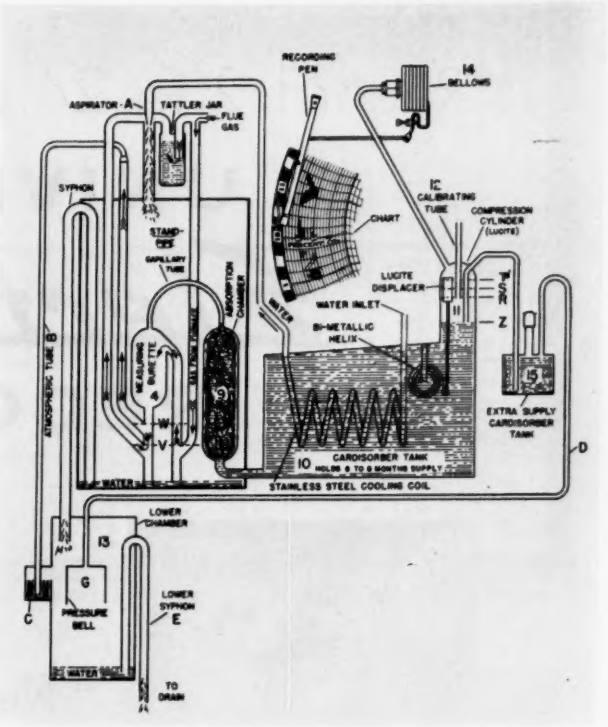
COMBUSTION METER RECORDS COMBUSTION EFFICIENCY CONTINUOUSLY

This system monitors efficiency of combustion of a fuel-burning process. It consists of a basic chemical CO_2 analyzer plus recorder, and a sampling system which includes a condensing unit.

The analyzer is based on the Orsat principle of volumetric measurement and chemical absorption. A sample of flue gas is automatically measured at a constant pressure and the gas is then absorbed by a special chemical (Cardisorber). The analyzer uses only water as actuating medium. The water, by aspirator (A), shown at the top, draws the flue gas in through a measuring burette (4). As the water rises, a measured volume of gas is trapped and forced into an absorption chamber (9), packed with steel wool moistened with Cardisorber where the CO_2 is completely absorbed. As some of the liquid thus is forced out into the storage tank (10), the level in the compression cylinder (11) is raised, air is forced out into bellows (14), and the recording mechanism is actuated. (When analyzer and recorder are mounted remotely from each other, a pneumatic capillary transmission tube is used.)

The sampling system's main components are the Venturi aspirator gas line filter and water-cooled condenser. Operation is continuous, with the excess flue gas being by-passed through the "tattler jar."

Source: The Hays Corp., Michigan City, Ind.; also General Catalog Section 58-D622.

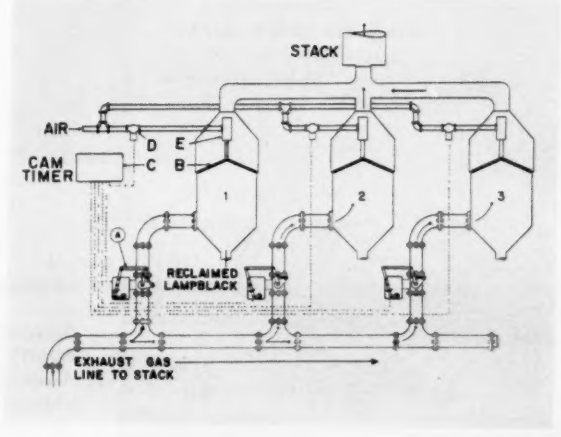


TIMER CYCLES EXHAUST TO SOLVE SMOKE PROBLEM AND RECLAIM LAMPBLACK

Engineers at Monsanto Chemical Company's Camden, N. J. lampblack plant were faced with a smoke nuisance problem and a high loss of lampblack in exhaust gases through the stack. The problem was solved as follows:

1. Motorized Valve (A) installed in the exhaust line to the stack, when open, allows flow of exhaust gases through the collector (1).
2. Filter (B) collects the lampblack particles and allows only pure gas to enter the stack.
3. Once every fifteen minutes the Cam Timer (C) closes valve (A), shutting off the exhaust flow through collector (1) to the stack and at the same time opens solenoid valve (D) in a compressed air line.
4. Pneumatic cylinder (E) is thus operated with a reciprocating motion, shaking filter (B) free of accumulated lampblack.
5. After one minute of filter shaking action, cam time (C) shuts off solenoid valve (D) and returns motorized valve (A) to its open position.

Proper time control and operation of valves and filter limit the amount of lampblack accumulating on filters (under normal operating conditions) before filter shake-down takes place. Timing must be accurate to permit correct cycling through one unit while other two units are passing exhaust to the stack.



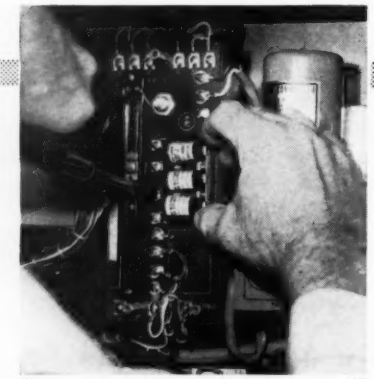
Results: The smoke nuisance problem was solved and a daily reclaim of 500 pounds of lampblack which was formerly lost in exhaust gases was realized.

Equipment used includes an ATC series 2406 Repeat Cycle Cam Timer (6 circuits) and three ATC type 2 Motorized Butterfly Valves (BF-33, 8″).

Source: Automatic Timing & Controls, Inc., King of Prussia, Penna., also Application Bulletin 102.

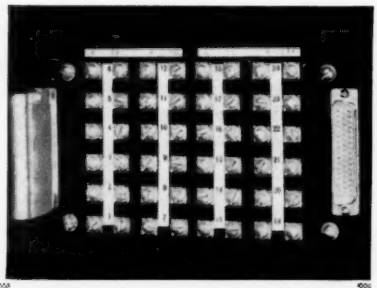
Record 2 to 24 points on the same

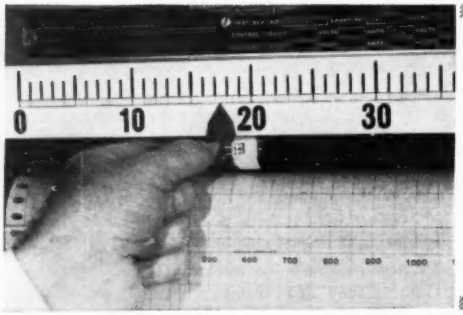
UNIVERSAL Electronik RECORDER



New modular design . . . and greater value than ever

CHANGING RANGE IS EASY—Loosen screws and slide out the range resistor card. Replace with a different card, tighten screws and the job is done quickly and easily.

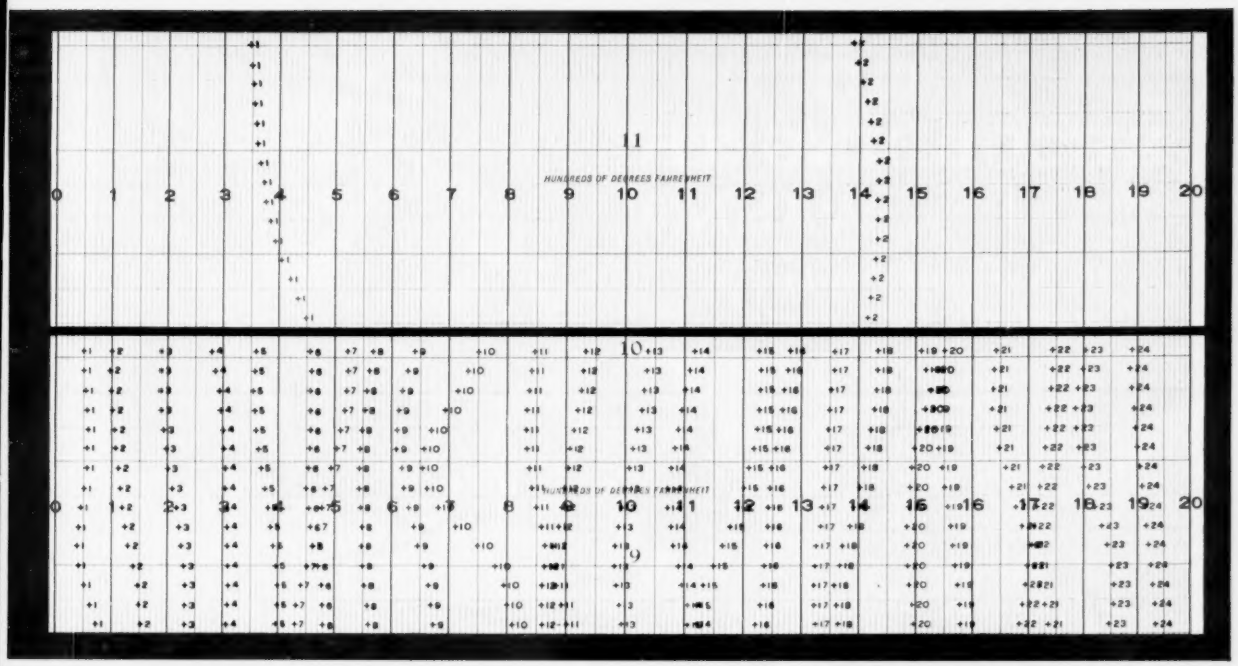




CHANGING NUMBER OF POINTS IS EASY—First, remove thumb-tight nut; slip off print wheel and indicator dial. Slip on new wheel and dial and replace nut. Second, replace one plug-in unit on extreme right of terminal board, and the instrument is ready to record any desired number of points.

CHANGING COMPENSATION IS EASY—Input terminal board comes out by removing one plug (extreme left) and four screws. Slide in the new board, replace the screws and plug and the compensation is changed. Reference junction is built into terminal board on reverse side.

CIRCLE 74 ON READER-SERVICE CARD



Now, you can record 2,3,4,6,8,10,12,16,20 or 24 points on one instrument—the new Universal *ElectroniK* Recorder. And you can change the number of points to be recorded in a matter of seconds. It's as easy as this: remove a thumb-tight nut and slip off the old print wheel and indicator dial. Slip on a new wheel and dial and replace the nut. Plug in the number of points wanted, and the job is done.

New modular design makes all *ElectroniK* instruments easier to use and maintain and a greater value than ever. This new design has also resulted in substantial manufacturing economies and appropriate price reductions. Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

CONSTANT VOLTAGE UNIT (Zener diode) eliminates batteries, standard cells, and standardizing mechanisms.

Honeywell

First in Control

SINCE 1885

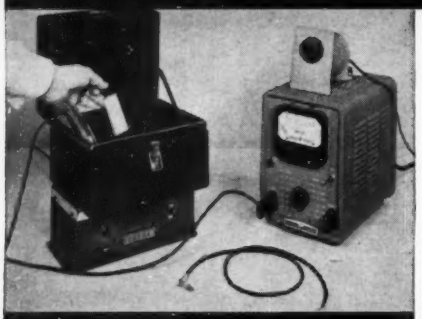
75th YEAR

PIONEERING THE FUTURE

CIRCLE 74 ON READER-SERVICE CARD

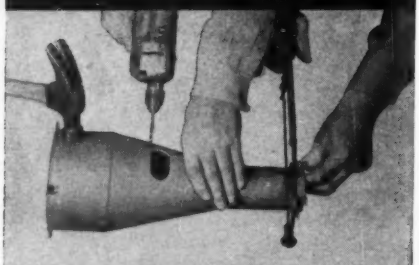
THE RECORDING THAT WASN'T

. . . It's happened to lots of magnetic tape users



Test factually demonstrates shielding effectiveness of Netic alloy material and enclosure design. Instrumentation used: magnetic field radiating source, AC vacuum tube voltmeter, Variac, pickup probe and Netic Tape Data Preserver. For complete test details and results, request Data Sheet 142.

For safe, distortion-free storage of large quantities of vital magnetic tapes. Designed for Military Establishments, Radio & TV Broadcasters, Automated Plants, Libraries, Laboratories, Gov't. Agencies, etc.



Composite photo demonstrating that magnetic shielding qualities of NETIC alloy material are not affected by vibration, shock (including dropping) etc. Furthermore, NETIC does not retain residual magnetism nor require periodic annealing.

Burton browne advertising

Maybe you've been one of these unfortunates . . . who've spent thousands of dollars . . . plus many man hours . . . to record valuable information on magnetic tapes . . . only to find the data useless from accidental distortion or erasure.

Unexpected exposure to an unpredicted magnetic field, and presto!—your valuable data is filled with irritating odd noises. Distortions may result in virtual data erasure.

Unprepared tape users never realize the danger of loss until it's too late.

Such losses have become increasingly common from damaging magnetic fields during transportation or storage. These fields may be produced by airplane radar or generating equipment or other power accessories. Also by generators, power lines, power supplies, motors, transformers, welding machines, magnetic tables on surface grinders, magnetic chucks, degaussers, solenoids, etc.

Since 1956, many military and commercial tape users successfully avoid such unpleasant surprises. Their solution is shipping and storing valuable tapes in sturdy NETIC Tape Data Preservers.

Data remains clear, distinct and distortion-free in NETIC Preservers. Original recorded fidelity is permanently maintained.

Don't take chances with *your* valuable magnetic tapes. Keep them *permanently clear* and *distinct* for *every* year of their useful life in dependable NETIC Preservers. Can be supplied in virtually any size and shape to your requirement. Write for further details today.

For complete, distortion-free protection of valuable tapes during transportation or storage. Single or multiple containers available in many convenient sizes or shapes.

MAGNETIC SHIELD DIVISION PERFECTION MICA CO.

1322 No. Elston Avenue, Chicago 22, Illinois

Originators of Permanently Effective Netic Co-Netic Magnetic Shielding

CIRCLE 77 ON READER-SERVICE CARD

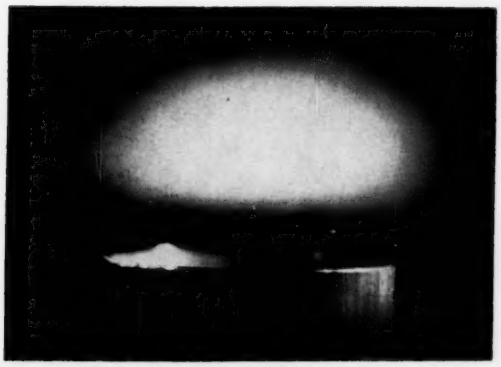


FIG. 1. ACETYLENE-OXYGEN flame on a 64-mm-diameter burner at 2-mm Hg pressure.

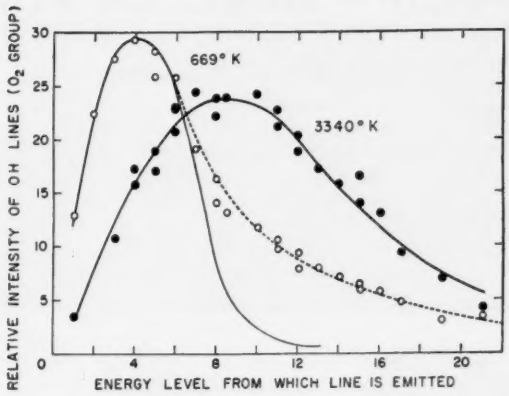


FIG. 2. DISTRIBUTIONS of OH emission line intensities in two electrical discharges. Calculated equilibrium curves are solid lines; intensity measurements are shown as experimental points.

FLAME TEMPERATURE DETERMINATION

NATIONAL BUREAU OF STANDARDS is conducting a program of basic research on the physical and chemical processes occurring in flames and other high-temperature gases. Spectroscopic methods are employed to observe hot gases in both flames and electrical discharges.

When present methods of temperature measurement are applied to certain systems of hot gases, several different temperatures are obtained. These temperatures must be related to the Thermodynamic or International Temperature Scales before valid thermodynamic calculations are possible. Detailed spectroscopic studies on well-controlled hot-gas systems are thus needed.

In measuring flame temperatures spectroscopically, molecular distributions are calculated from observed spectral intensities and compared with distributions predicted theoretically for certain temperatures. For the distribution calculations the relative intensities of a group of related spectral lines emitted or absorbed by the flame are first measured. Then from these relative intensity values, and the known values for the probabilities of emission or absorption of radiation, the numbers of molecules in the various energy levels giving rise to spectral lines are determined.

In using the observed distribution of molecules in the possible energy states to study rate processes and equilibrium conditions, three general types of behavior are found. Essentially they differ in the amount of interaction, or coupling, between the various groups of energy states in the system.

Strong Interaction

The simplest case is complete equilibrium. Here all the observed energy levels correspond to the same temperature, so that the measurements constitute a reliable temperature determination. An example of this situation is a recent investigation of the emission spectrum of iron atoms added to a hydrogen-oxygen flame. Here the intensity distribution in the emission spectrum corresponds to a temperature of 2845°K.

No Interaction

A second, quite different type of behavior is found in observing the OH-radical emission spectrum in the reaction zone of an acetylene-oxygen flame. Under certain conditions observations reveal an abnormal rotational distribution in the electronically excited state, corresponding to a temperature approaching 10,000°K. However, the heat released in burning is sufficient to produce an equilibrium temperature no higher than 2000°K.

Partial Interaction

In the third possible type of behavior, the interaction between the several groups of energy levels is only partial, rather than being almost complete as in the hydrogen-oxygen flame, or non-existent as in the abnormal OH spectrum mentioned. In this intermediate case the distribution of molecules in the accessible energy levels, and therefore the apparent temperature, is affected by molecular collisions.

SPECIFY MOELLER FOR QUALITY INSTRUMENTS

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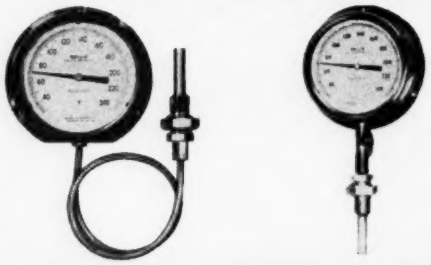
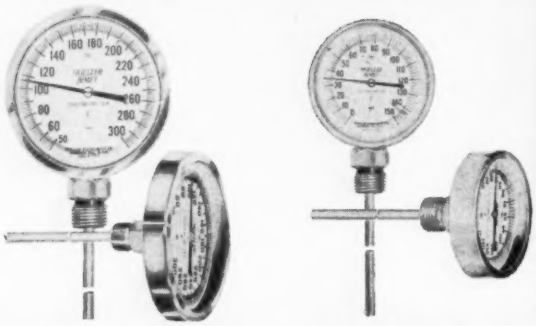
Mercury Actuated with anti-parallax dials to assure accurate reading. Made in 4½", 6" and 8½" sizes with flexible tubing, adjustable stems, single or two pointers, with or without electrical contacts. Can be furnished with plain bulb, union connection bulb or separable sockets in all lengths and alloys. Ranges available from minus 40° to plus 1000°F. or its equivalent in Centigrade.





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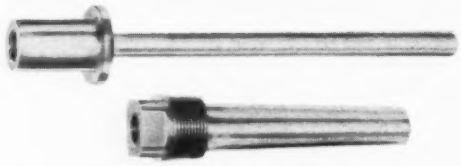

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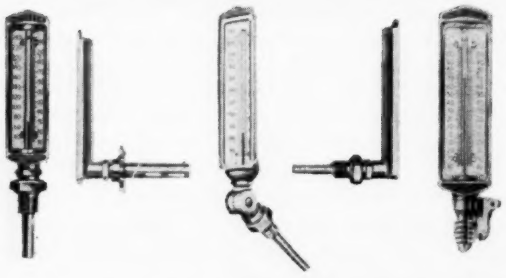

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CIRCLE 76 ON READER-SERVICE CARD

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

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MASS FLOW

The only type of flowmeter which does not require specific-gravity, pressure, and temperature corrections is a meter which is sensitive only to the mass rate (weight rate) of flow.

FLOWMETERS fall into two distinct categories —(1) inferential meters and (2) true mass flowmeters—which differ fundamentally from each other.

The inferential meter does not sense mass flowrate. It usually uses a conventional volumetric metering element (area, head or volume meter) in conjunction with another device for sensing the density, velocity, temperature or other variables that allow the computation of the mass flow rate.

A true mass flowmeter, however, requires only one primary element which is sensitive to the mass rate of flow. The output of the meter thus is independent of the variable physical properties of the stream such as pressure, temperature, density, viscosity, turbulence (Reynold's Number), and ambient conditions, including barometric pressure and temperature. A number of true mass flowmeters have been devised which will produce an output that is directly proportional to the mass flowrate[1].

In one such instrument (Fig. 2) the principle used is measurement of the force required to produce a velocity change. The meter employs three elements—an impeller, a turbine, and a gyro integrator. The flowing stream of gas first passes through the impeller, which is driven by a synchronous motor at a constant speed. The outer periphery of the impeller and turbine each comprise a series of straight vanes parallel to the axis of rotation. In passing through these vanes of the impeller the gas stream is given the same angular velocity as

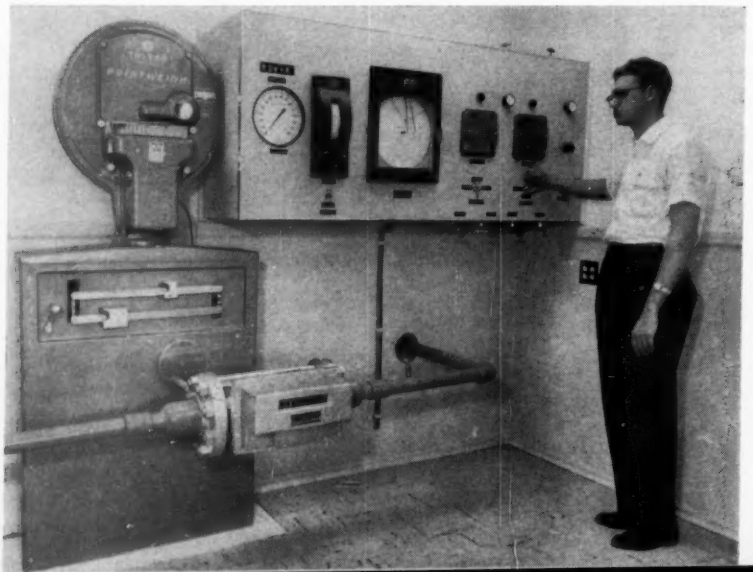

FIG. 1. FLOW PROVER control room. Mass flowmeter is unit with counter.

MEASUREMENT

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the impeller. Therefore, the gas stream has a specific angular momentum when it exits from the impeller.

The turbine is located close to the impeller. The rotating gas stream enters the turbine from the impeller. As the turbine element is restrained and cannot rotate, it removes the angular rotation of the stream (angular momentum that the impeller originally supplied). The torque required to restrain the turbine is directly proportional to the mass flow rate.

Basic Theory

The theory of the mass flowmeter can be explained with a few fundamental laws of dynamics.

Newton's Second Law gives the torque on the turbine if all of the angular momentum imparted to the stream by the impeller is removed by the turbine:

$$T = dH/dt \qquad (1)$$

where T is torque on turbine, H is angular momentum of rotating stream, and t is time.

Consider a small mass of fluid (dm) which leaves the impeller in the time interval dt. The angular momentum of the small mass can be expressed:

$$dH = \omega\, dI \qquad (2)$$

where ω is angular velocity of the impeller, dI is mass moment of inertia of the small fluid mass (dm) about the axis of the impeller.

It is convenient to express the mass moment of inertia in terms of radius of gyration, k, which depends mainly on the distance between the axis of rotation and the center of the passages, and only to a small extent on the shape of passages:

$$dI = k^2 dm \qquad (3)$$

Combining equations (2) and (3) and dividing by dt:

$$dH/dt = \omega\, k^2\, (dm/dt) \qquad (4)$$

Note that the quantity (dm/dt) is the mass rate of flow (or the rate at which the fluid leaves the impeller).

Substituting (4) into (1):

$$T = \omega\, k^2\, (dm/dt) \qquad (5)$$

Equation (5) illustrates that the torque imposed on the turbine is proportional to the mass flow rate (dm/dt) and that the proportionality constant ($\omega\, k^2$) depends on the angular velocity of the impeller and the dimensions of the turbine.

The angular velocity (ω) is maintained constant by a synchronous motor, and the radius of gyration (k) is simply a geometrical constant.

Note that the output of the meter is in terms of mass (weight) per unit of time, such as pounds per hour. However, in practice, flowrate is usually

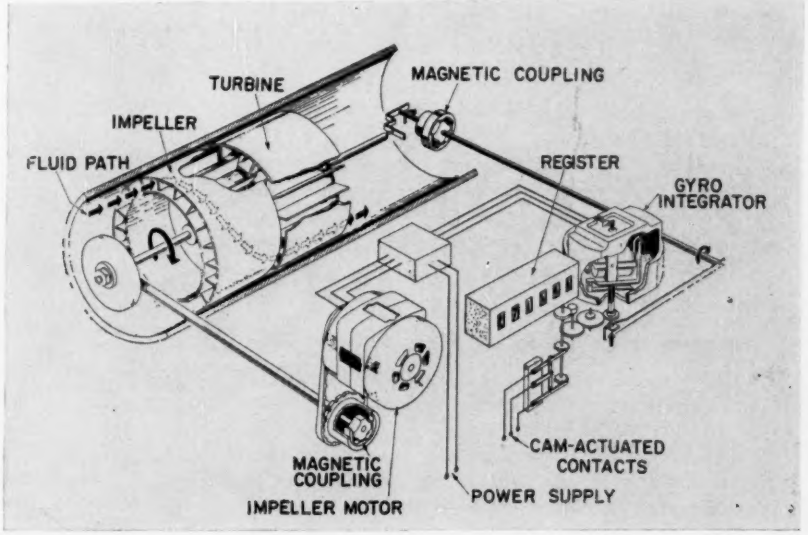

FIG. 2. FUNCTIONAL diagram of mass flowmeter with gyro integrator.

of secondary interest and is used only for setting rates, dispatching, etc. The item of primary interest usually is the *integrated* (totalized) reading over a period of a week or month.

Integration to Total Mass

A precise and simple integrator—a gyro-integrator—has been designed into the meter to provide integration without manual calculation or charts. The gyro-integrator is based on the principle that a two-gimbal gyroscope will precess about its major axis at a *rate* proportional to the *torque* applied about its minor axis.

The torque generated at the turbine (mass flowrate) is transferred by a system of linkages to the minor gimbal of the two-axis gyroscope, as shown in Fig. 2.

The relations of torque, angular momentum of the gyro rotor, and precessional angular velocity of the gyroscope can be expressed:

$$\Omega = T_g / I_g \, \omega_g \qquad (6)$$

where Ω is precessional angular velocity, T_g is torque applied to the minor gimbal of the gyroscope about its minor axis, I_g is moment of inertia of the gyro rotor, and ω_g is angular velocity of the gyro rotor.

As T_g comes directly from the flowmeter turbine (through a magnetic coupling) it is proportional to the flowmeter turbine torque:

$$T_g = K_p \, T \qquad (7)$$

where K_p is a constant.

Substituting T from (5) in (7):

$$T_g = K_p \, \omega \, k^2 \, (dm/dt) \qquad (8)$$

Substituting T_g from (8) in (6):

$$\Omega = (K_p \, \omega \, k^2 / I_g \, \omega_g) \, (dm/dt) \qquad (9)$$

As ω and ω_g both are proportional to the line frequency supplied to the two synchronous motors, the integrated reading is essentially independent of the line frequency supplied. The values of K_p, k and I_g are design constants and it may be considered that:

$$K_p \, \omega \, k^2 / I_g \, \omega_g = A \qquad (10)$$

$$\text{and } \Omega = A \, (dm/dt) \qquad (11)$$

so that the precessional angular velocity is proportional to the mass rate of flow.

To integrate mass flowrate, it is necessary only to count the revolutions of the gyroscope about its major axis. This is done with a conventional cyclometer and counter wheels as shown in Fig. 2.

Advantages of Measuring Mass Rate of Flow

The basic advantage of a mass flowmeter is that it measures quantity directly without recourse to either theoretical or empirical correction factors. Furthermore, the mass flowmeter does not require established base conditions. The reading is in its most useful form the instant it is taken from the integrator.

For example, in the consumption of natural gas the customer is interested in either (1) the heat that may be obtained from the gas or (2) the quantity of gas that is available for converting into a product. Both are functions of the mass of the gas. The heating value per pound of pure natural gases varies only a fraction of a percent over a wide range of gravities, whereas the heating value per standard cubic foot may vary as much as 25%.

Another significant advantage of the mass flowmeter is that it does not require a meter run. The impeller provides all of the straightening that is required ahead of the turbine. Hence the meter can be installed in a relatively small space.

The size and weight of the meter is small; this simplifies installation, operation and inspection. The size is comparable to a senior orifice fitting without recorder (Fig. 1).

The pressure drop across the meter is small and varies with flow rate (as all fixed-resistance devices must). The meter currently under test has a pressure drop of about 0.25 psi at its nominal pressure and flow rating. Note that the flow stream is not blocked in the event of meter failure.

Proving Mass Flowmeters

A suitable prover (calibrator) has been constructed and has been in use for the past year in developing the flowmeter (Fig 1). The basic principle is based on weighing pressure vessels containing high-pressure gas.

Downstream of the vessels a pressure-regulating valve controls the pressure of the meter during test.

The meter is located downstream of the pressure-regulating valve. The flow rate is regulated downstream of the meter by two critical-flow orifices exhausting to the atmosphere at equal rates and in opposite directions, thus cancelling out the exhaust reaction. During a run the vessels and their contents are continuously weighed to a high degree of accuracy. The registration of the meter is compared to the scale indication to provide calibration data. The prover provides a simple and direct method for calibrating the mass flowmeter and is free from empirical or theoretical corrections.

The meter is provided with adjustments for both zero and span so that it can be calibrated accurately. These adjustments can be sealed after calibration to prevent tampering.

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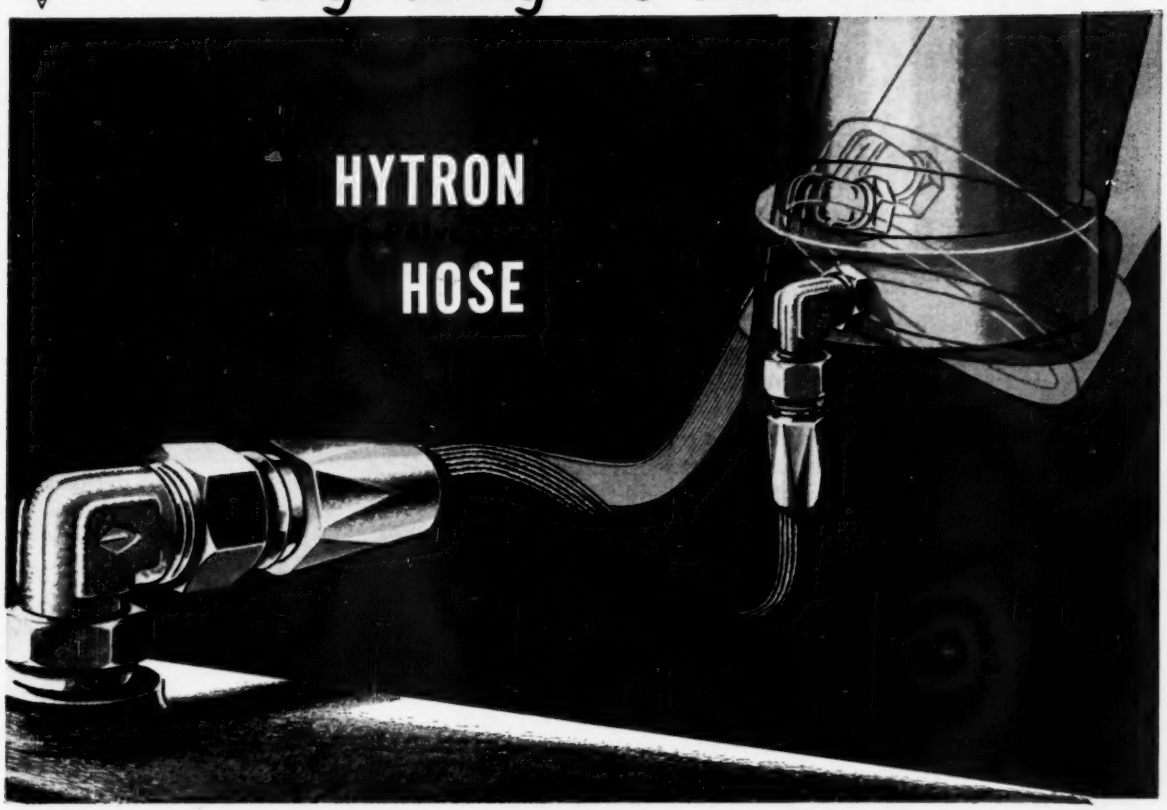


FAR GREATER FLEX-IMPULSE CAPACITY...
IMPROVED PRESSURE HOSE PERFORMANCE

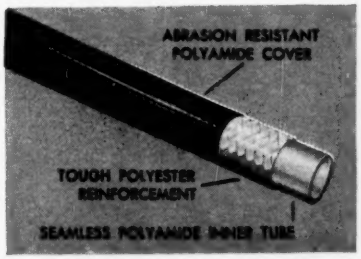
Imperial unveils a completely new concept in pressure hose — opening new opportunities in hydraulic and pneumatic circuitry design, bringing new economies and advantages to thousands of other hose applications.

Hytron was created to solve many of the problems encountered in using S.A.E. types 100R1 and 100R5 hose. It radically reduces hose size and weight, offering smaller O.D. for equivalent pressure capacity and I.D.

Flex-Impulse Test Results

Hytron superiority under punishing flex-impulse conditions has been clearly demonstrated. Comparable 24" lengths of hose with couplings were subjected to cycles from 0 psi to 3500 psi at one-second intervals. Simultaneously they were flexed at 60 times per minute.

After 57.4 hours the S.A.E. 100R5 single wire braid rubber hose burst near a coupling. It took 415.5 hours — *over seven times as long* — before the Hytron hose failed.



Note that there is *no wire braid* in Hytron hose. This eliminates one of the major causes of fatigue failure. Hytron is 80% lighter in weight, and, unlike wire braid rubber hose, retains virtually all of its flexibility under pressure.

Imperial Hytron hose operates in a burst pressure range from 9000 to 12,000 psi, depending on size and temperature. It is recommended for continuous service with fluids from −40 to 225°F, and for intermittent service to 250°F. Hytron is unaffected by nonflammable hydraulic fluids up to 180°F and flammable fluids up to 225°F.

Hytron hose is available in exceptionally long lengths. Furnished as factory-made assemblies, or with easy-to-install reusable couplings. Hytron couplings are of a new design that greatly minimizes flow restriction, offering up to 157% greater flow capacity.

IT'S IN THE BOOK

A new engineering report on Hytron hose and couplings contains detailed test results and performance figures. Send for your copy of Form No. NEPR-500 today.

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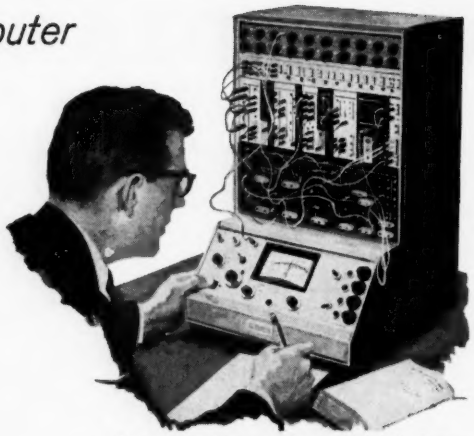
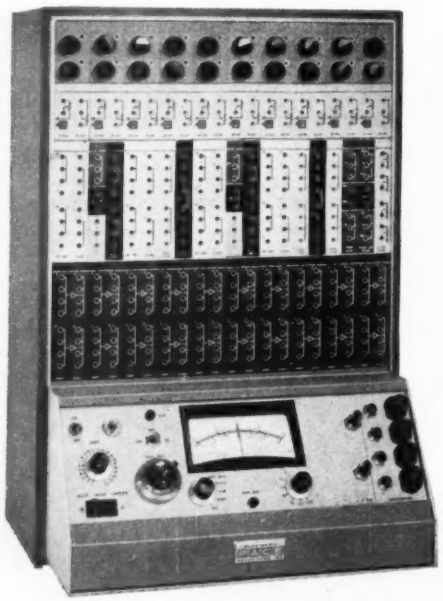
EAI *Transistorized Analog Computer*

A WIDE RANGE OF SOLUTIONS AT DESIGN ENGINEERS' FINGERTIPS...



PACE® TR-10, the first all transistorized desktop analog computer, puts proven high-speed computation right where it's needed – on the desks of busy engineers. With this easy-to-use simulator, you can quickly solve many problems without waiting for scheduled access to large-computing systems. Though compact in size, the TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Up to 20 amplifiers, plus linear and non-linear computing components are contained in one compact cabinet with no external racks. The TR-10 permits rapid evaluation of different design approaches. It demonstrates the performance of a conceptual or drawing-board design prior to construction. Thus it saves time and money normally required for multiple test models with cut-and-try engineering.



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The TR-10 is especially useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies and many other problems involving dynamic conditions. Fast answers to problems posed by new design ideas immediately determine feasibility of projects. With the TR-10, engineers can explore new ideas as they occur – concentrate valuable time on the most promising area of study.

(Applications notes are available describing typical problem solutions.)

How Do You Use The TR-10?

First—Represent in equation form the physical system to be studied.

Second—Select through a simple computer diagram the computing components required to perform the calculation (programming).

Third—Interconnect these components on the computer (problem patching) and set problem parameters with adjustable controls.

Fourth—Run the problem with results presented graphically on an accessory recorder or oscilloscope.

You now have an electronic analog *model* of the physical system under study. You can manipulate design parameters quickly, running comparative solutions without becoming involved in repeated calculations. With the TR-10 you can rapidly develop truly optimum designs.

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PACE TR-10 Analog Computer, including components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs and arbitrary functions.

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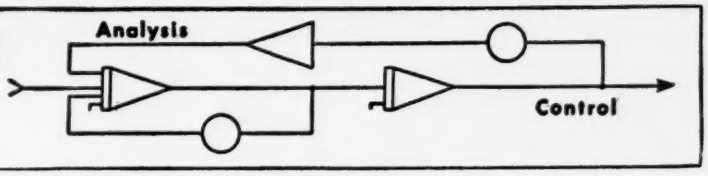
The SIMULATION COUNCIL Newsletter



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Bits

This month the whole Newsletter is bits! We report on six talks from the Eastern Simulation Council meeting of 19 October 1959 and three from the Western Simulation Council. To get them all in we had to cut **PIECES** to bits.

The authors and their titles are as follows:

EASTERN SIMULATION COUNCIL

The Method of Steepest Ascents—*Walter Brunner*, Princeton Computation Center

Automatic Data Reduction—*Joe Feitler*, International Business Machines Corp.

Special Electronic Switching Circuits—*Arthur Rubin*, Princeton Computation Center

Correlation—*Ian Hay*, Princeton Computation Center

Design and Applications of a Magnetic Drum for use with Analog Computers—*John Strong*, Electronic Associates, Inc.

Fitting Reaction Rate Constants from Plant Data—*John Munson*, E. I. DuPont de Nemours Company, Inc.

WESTERN SIMULATION COUNCIL

Spectral Characterization of Control System Nonlinearities—*R. B. McGhee*, Hughes Aircraft Co.

Determination of Optimum Production Tolerances by Analog Simulation—*R. B. McGhee* and *A. Levine* (both of Hughes)

A Stochastic Method of Solving Partial Differential Equations Using an Analog Computer—*Kuei Chuang* (Univ. of Michigan) *L. F. Kazda* (Univ. of Mich.) *T. G. Windeknecht* (Space Technology Labs)

For a welcome letter to your Ed, a little miscellaneous **Info,** and to see what I have done to the above authors' efforts under **Pieces,** read on at your own risk!

Information (Without Theory)

Illustrating the advantages of feedback (or simply cooperation to those who are more socially than technically minded), we have a set of Data Sheets sent us by Milt Aronson, your Ed's Ed. They cover the AD-1 Electronic Differential Analyzer, a general-purpose analog computer which emphasizes modular construction technique, computer systems with as few as four and as many as 32 amplifiers with fixed-board patching. A removable prepatch board assembly can be added at any time with no cost penalty, after which the AD-1 computer can be expanded to as many as 64 amplifiers. All computing elements are housed in 4½" x 14" modules which slide forward out of the cabinet for easy access.

The seven basic types of modules are power supply; control panel; four-amplifier integrator-summer; four-amplifier inverter-summer; coefficient-pot panel; function generator; repetitive operation.

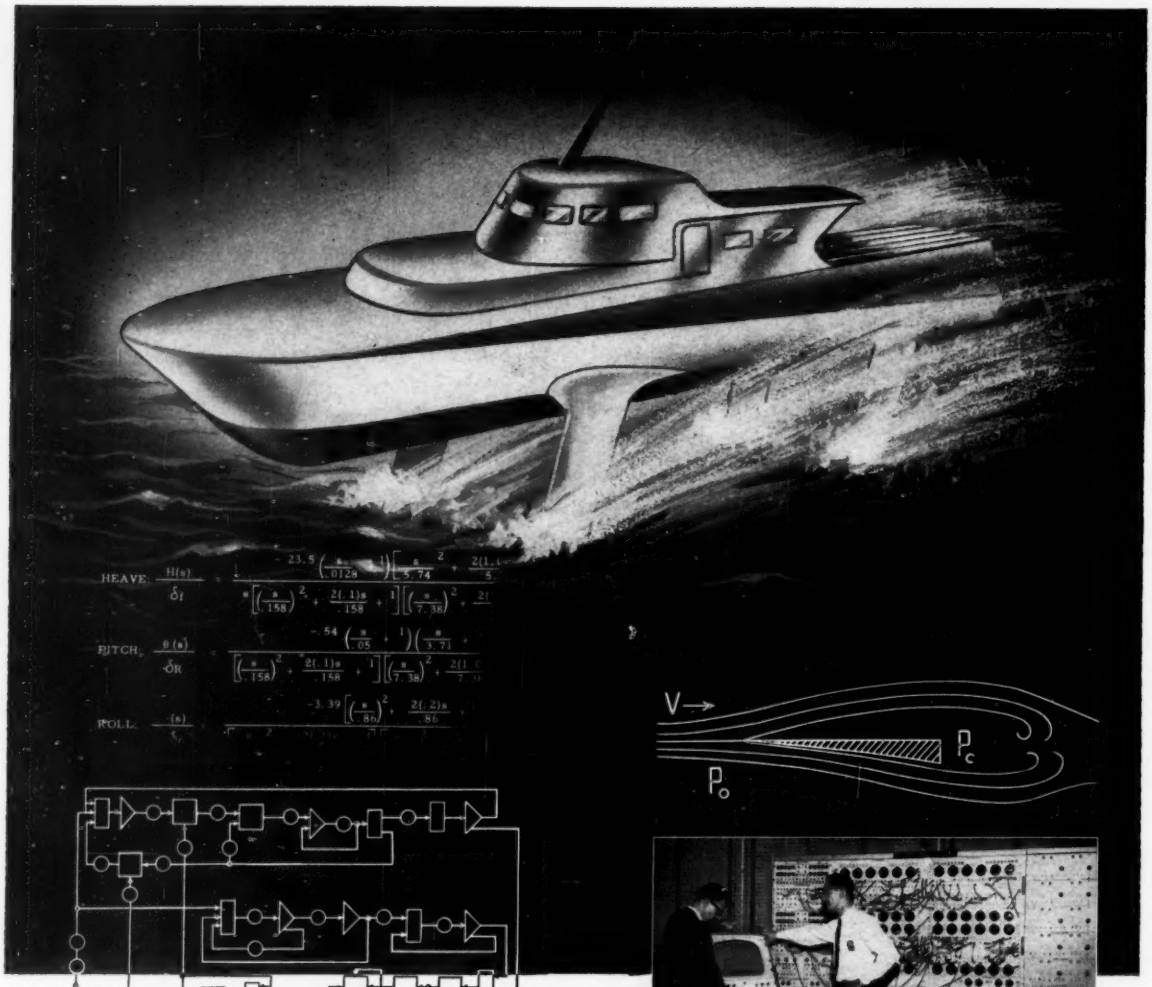
No price is mentioned. For more details check with Applied Dynamics, Inc., Box 2068, Ann Arbor, Michigan.

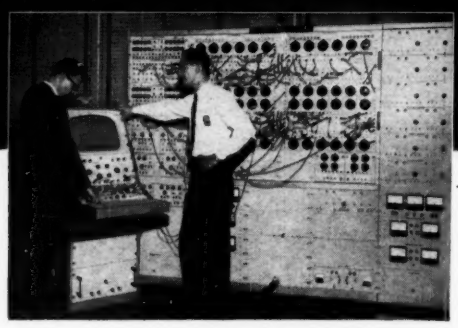
Milt also notes that General Computers (9000 West Pico Blvd., Los Angeles, Calif.) too has introduced a small modular analog computer.

Granino Korn has sent us a copy of University of Arizona ACL Memorandum #15, "Analog Computers in the Electrical Engineering Department" which we found most interesting and believe others would too. It covers the instruction program, facilities, an outline of development work, the subject of experience for graduate students, some analog computer references, and a description of the Department of Electrical Engineering Analog Computer Laboratory in detail, even down to some of the circuitry.

* * * *

While their petition for membership





GPS COMPUTER AT HAMILTON STANDARD, BROADBROOK, CONN.

Simulation Studies of Hydrofoils at HAMILTON STANDARD ELECTRONICS

The Electronics Department of Hamilton Standard Division, United Aircraft Corporation is designing stabilization and control systems for hydrofoil craft. The GPS Statistical Analog Computer is the one being used in the system optimalization. The wealth of practical experience that Hamilton Standard Electronics has acquired in stabilization control of helicopters is being applied to the stability control problems of hydrofoil craft.

Dynamic characteristics as well as the performance of the CONTROL-HYDROFOIL system in the presence of random disturbances caused by complex wave motion over the full range of sea state conditions are being examined. Dynamic and probabalistic responses are generated simultaneously and directly on the GPS Statistical Analog Computer with a considerable savings in time and manpower.

Why not investigate the computation possibilities of the GPS Statistical Analog Computer in your research.

GPS Products: *Compressed — time scale analog computers and high-speed statistical computers*

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and their territory are being considered by the Simulation Councils Inc. Board of Directors, we are happy to announce that the next meeting of the Rocky Mountain Simulation Council is scheduled for 24 June 1960 at the Utah Division of Thiokol Chemical Corporation, Brigham City, Utah. *Maughan S. Mason* (Thiokol) is the man to get in touch with.

EASTERN S/C MEETING OF 19 OCT. ON "UNUSUAL APPLICATIONS OF COMPUTERS"

The Eastern Simulation Council held a meeting at the Princeton (N.J.) Computation Center of Electronic Associates Inc. on 19 October 1959 to hear six papers and to participate in a discussion of "Unusual Applications" of analog computers.

Brunner on Steepest Ascent

The purpose of the first paper, "Steepest Ascent" by *Walter Brunner* (EAI Princeton Computation Center) was to introduce the method of steepest ascent as a general tool for solving a wide variety of problems encountered in analog computation. The method is not restricted to analog computers and can be equally well applied to digital computation and certain control problems. The method of steepest ascent is a broad concept which gives a systematic approach to complex algebraic, adaptive control, and redundant integrator compensation problems, and even in many simpler problems produces more sophisticated circuitry than is possible by standard techniques.

Walter's paper is a mathematically sophisticated (i.e., to your Ed., difficult) treatment of the method as applied to the minimization of $\sum_{i=1}^{m} G_i\theta_i^2$ and of $\sum_{i=1}^{m} G_i|\theta|$ in the cases of four-quadrant division and the harmonic oscillator. His equations and the corresponding analog computer diagrams are shown in Figs. 1 through 4.

For an explanation of the mathematics your Ed. refers you to the author before he gets himself involved.

We also repeat the references given in our February *Newsletter*:

1. Simulation Council Newletter, *Instruments and Automation*, pp 1546-7 Vol. 31, September 1958.
2. F. L. Gephart, "Linear Algebraic Systems and the REAC," Math. Tables and other aids for Comp., 6, pp 190-203, (1952).
3. H. F. Meissinger and L. Levine, "An Automatic Computer Circuit for Solving Polynomials and Finding Root Loci." *IRE Convention Record*, 1957. Part 4, pp 164-172.
4. I. B. Pyne, "Linear Programming on an Analog Computer," *AIEE Trans.* 1956, Part I, pp 139-143.
5. O. L. Davies, *Design and Analysis of Industrial Experiments, Chapter* 11, Hafner, New York, 1956.

Feitler on Automated Computer

The next paper was "An Automated Analog Computer" by *J. Feitler* (International Business Machines Corp., New York, N.Y.). This paper makes a strong case for automatic comparison of system performance criteria, describes a technique for accomplishing this, and illustrates the technique as applied to a study of a pulse transformer.

In general, the technique is to first determine the characteristics of interest and identify the voltages in the simulation which represent these characteristics. Then a method of measuring these voltages at the critical time of interest and of storing and subsequently recording these measurements must be devised.

In the case of the pulse transformer, the characteristics of interest were (Fig. 5): the output voltage maximum, the peak overshoot, the pulse width, and the recovery time. In this example it is apparent that the output

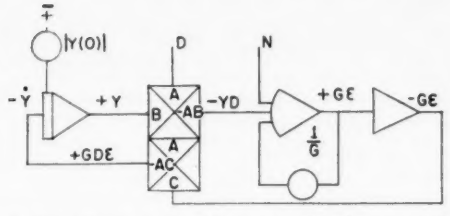


Fig. 1. Equations: $\epsilon = DY - N$; $dY/dt = -GD\epsilon$. Four-quadrant division based on minimizing $S = \epsilon^2$

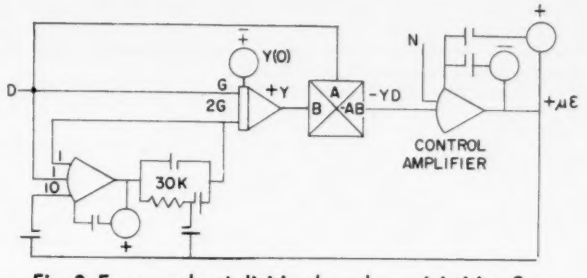


Fig. 2. Four-quadrant division based on minimizing $S = G|\epsilon|$ to implement $dY/dt = \pm GD$

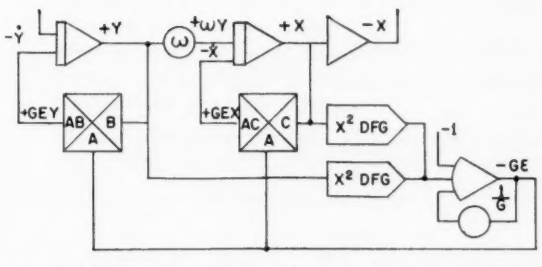


Fig. 3. Harmonic oscillator with amplitude correction based on minimizing $S = G\epsilon^2$, to implement $dx/dt = -\omega Y - G\epsilon X$; $dY/dt = \omega X - G\epsilon Y$

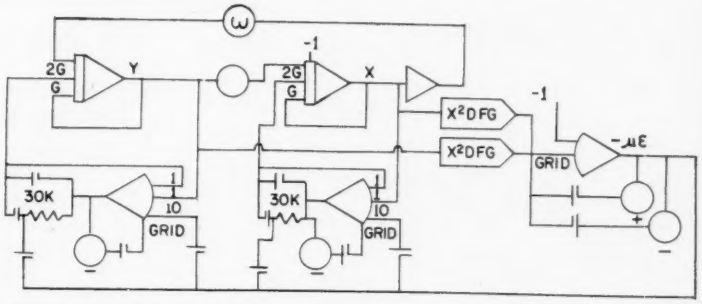
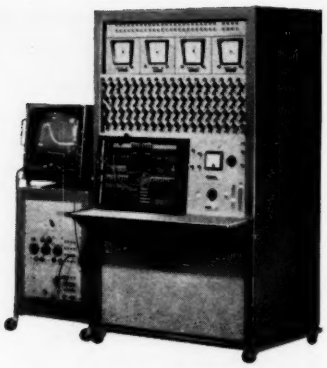


Fig. 4. Harmonic oscillator with amplitude correction based on minimizing $S = G|\epsilon|$ to implement $X = \omega Y \pm GX$; $Y = \omega X \pm GY$



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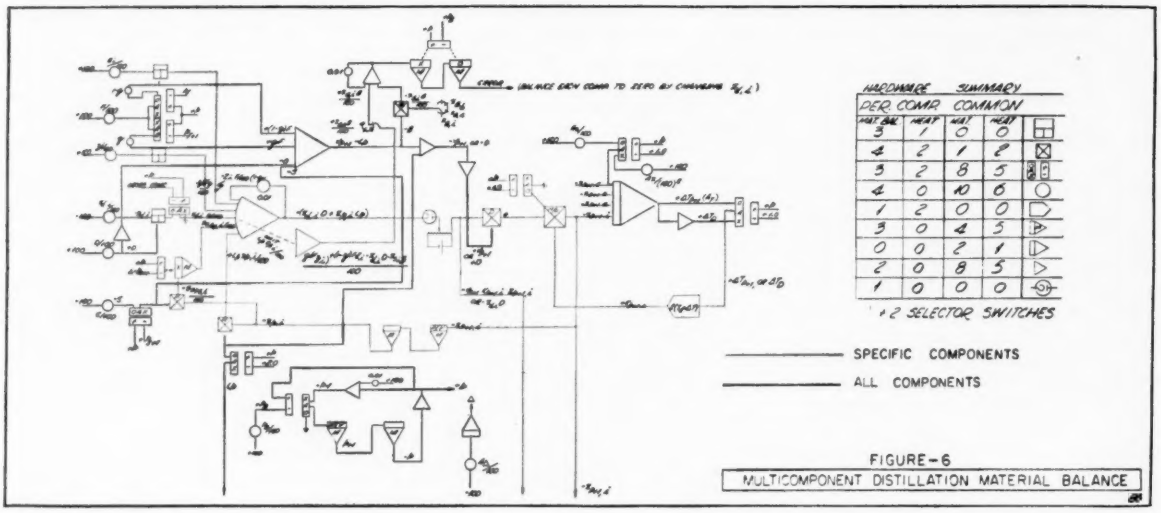

Multi-component Distillation Material Balance,
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For the complete 13-page design digest of the multi-component distillation problem-solution, request CSI form #80-1-5-001.

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voltage maximum occurs when the first derivative of the output voltage becomes zero for the first time. The peak overshoot occurs when the time derivative of the output is zero for the second time. An elapsed time measurement is required to determine the pulse width and the recovery time of the response. This can be done by noting that the pulse width is equal to the elapsed time between the start of the output pulse and the instant when the output voltage is equal to zero for the first time. Similarly, the recovery time is the elapsed time between the end of the pulse width measurement and the instant when the output voltage has been damped out and reaches a predetermined value, such as one percent of peak output voltage.

The next step is to translate the verbal statements designating the points of comparison into a logical design using available analog-computer components. Boolean algebra then can be used to determine the necessary switching network.

The analog-computer parts used in the illustration are relay amplifiers and relays (for selecting the voltages to be measured and the times for measuring them), integrators (for holding these measurements), a servomultiplier for simultaneously changing parameters and the abscissa on the plotting board), and an x-y plotter.

Application of the technique to most any kind of system evaluation would require the use of similar analog elements, but as the numbers and the interconnections would vary with the problem and the parameters of interest, we will not give the details of Joe's example here but leave "as an exercise for the student" the applications of the principles to problems of interest to our readers.

Brunner Landauer and Rubin on Electronic Switches

The third paper of the day, "High-Accuracy Electronic Switches for Analog Computation" by *Walter Brunner, P. Landauer,* and *Arthur Rubin* (all of Princeton Computation Center) showed the basic circuit of an electronic switch made with components usually available on an analog computer patch panel. It then gave equivalent-circuit diagrams and equations used to analyze the operation of the switch. However, as the speaker subsequently came up with a circuit of which he said, "One can have one's cake and eat it too," we will not spoil our readers' appetite for cake by requiring that they first digest the material on the basic circuit.

The paper pointed out that the basic switch was equivalent to a single-pole single-throw switch, and that normally one wishes to simulate a double-throw switch. It then showed analog circuits for simulating the type of single-pole double-throw switches wherein the arm switches between two different quantities, and also the other type wherein a single quantity is switched to two different points.

These are shown in Figs. 6 and 7, and the "cake too" circuit in Fig. 8. Of this circuit the authors say: "This is a perfect hard limiter since the feedback insures that the circuit is independent of diode characteristics (especially near the break point of the diodes)."

By changing the sign of both reference voltages the diodes are cut off and e_{out} is a perfect zero. Therefore the circuit can also be used as a gating circuit.

$e_{limit} = 500K\ e_s/(R + 500K)$
if $e_s = 100$
$e_{limit} = (500K)\ (100)/(R + 500K)$

To limit at 100 volts is impossible, but by making R say 3K, we can limit at

$e_{limit} = (500)\ (100)/503 = 99.4v$

Practical values of R can be anywhere from 5K to 100K (provided e_o is not required to be as large as 90 volts.)

Also, in this scheme, the control voltage must be large when the bridge diodes are conducting, and can be relatively small (say 5 or 10 volts) when the gate is open ($e_o = 0$).

This bridge circuit is equivalent to a single-throw switch, and is similar

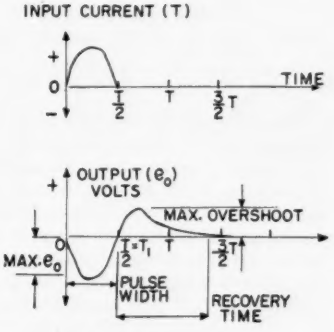


Fig. 5. Response of a pulse transformer. →

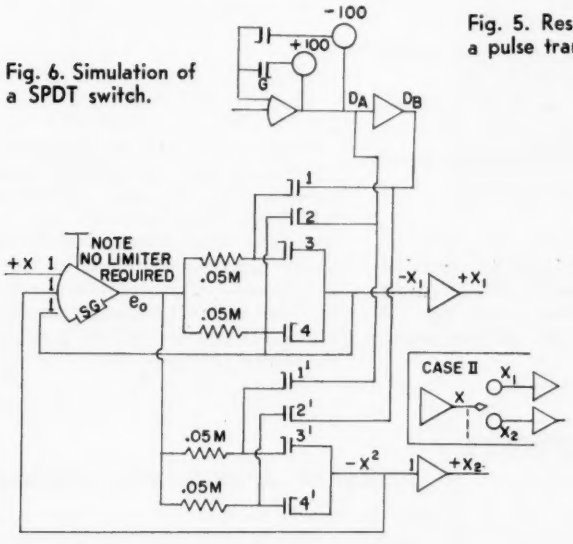


Fig. 6. Simulation of a SPDT switch.

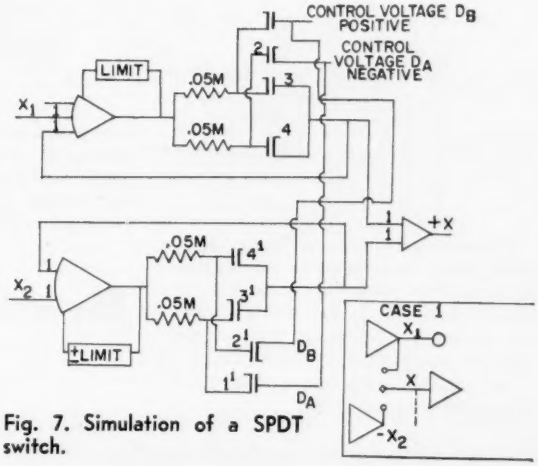
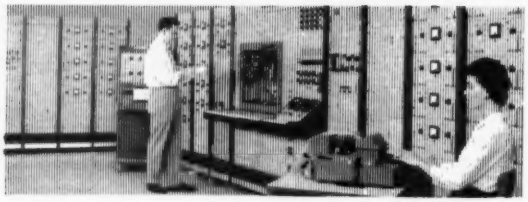


Fig. 7. Simulation of a SPDT switch.



SPEAKING WITH EASE®

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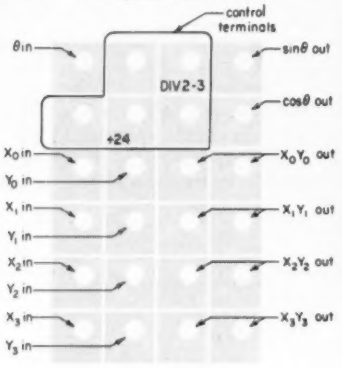
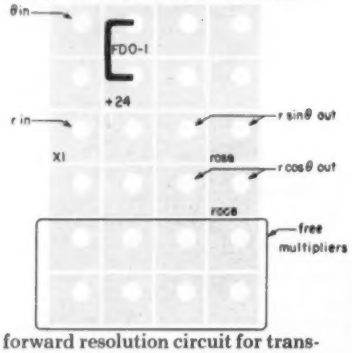
Electronic Resolution Circuits Formed Automatically

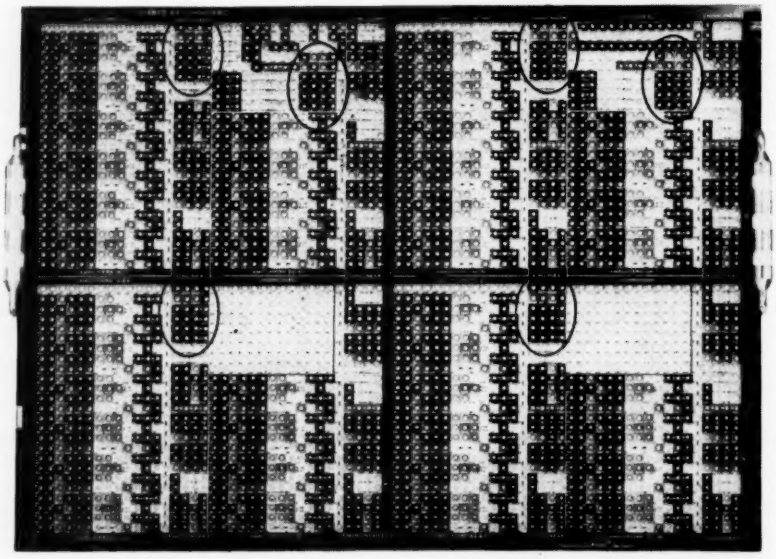
Complete electronic resolution circuits—forward or inverse—can be formed by inserting a single patchboard shunt. The shunt actuates relays that make all necessary connections between sine-cosine function generator, multipliers and amplifiers. Upon removing the shunt, the function generator and multipliers become immediately available for independent use with input and output terminals on the patchboard.



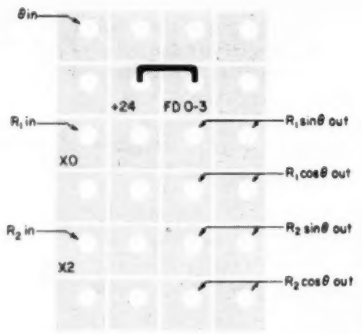
The 24-terminal resolver area contains input and output terminals for one sine-cosine function generator and four multipliers. With the control terminals untouched, all five units are completely independent. Multipliers 2 and 3 may be converted to dividers by connecting a patchboard shunt from the +24v terminal to the "DIV 2-3" control terminal.



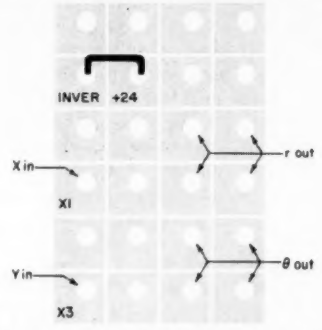
A forward resolution circuit for translating polar to rectangular coordinates is formed by connecting a patchboard shunt from +24v to the "FD 0-1" control terminal. Multipliers 0 and 1 are used in the resolution circuit; multipliers 2 and 3 are free for use elsewhere as multipliers or dividers.



Circled areas on new EASE patchboard are 24-terminal clusters with input and output terminals for forward and inverse resolution circuits. Clusters also contain input and output terminals for four multipliers that may be used independently.



Forward resolution of two parallel vectors is obtained by connecting a patchboard shunt from +24v to the "FD 0-3" control terminal. All four multipliers are employed.



Inverse resolution (translating rectangular to polar coordinates) is accomplished by shunting +24v to the "INVER" control terminal.

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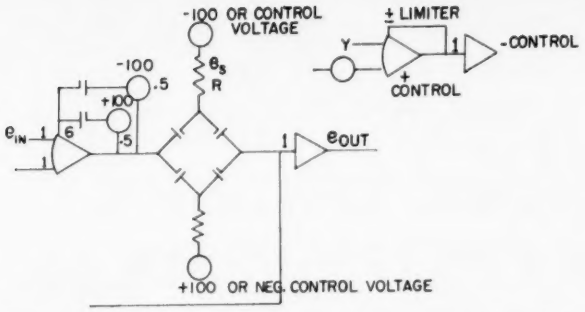

Fig. 8. "Have cake—can eat" analog simulation of either a hard limiter or SPST switch.

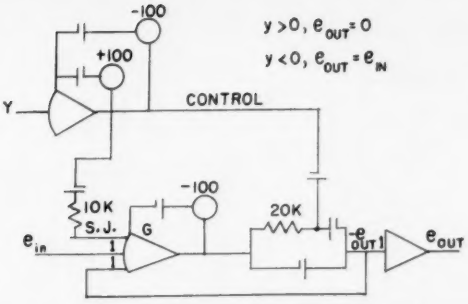

Fig. 9. A "cheap" simulation of SPST switch.

to the basic circuit shown previously, requiring the same number of diodes and amplifiers.

The simulation of a double-throw switch also leads to the same type of circuits as shown in Figs. 6 and 7.

A third "cheaper" circuit is shown in Fig. 9.

The control voltages need only be −10 volts and +8 (slightly larger than zero).

By reversing all the diodes the logic operation by y is also reversed.

This circuit's advantage over the previous circuits is less equipment.

Hay on Cross-Correlation Analysis

The next talk was "Continuous Cross-Correlation Analysis of Tape-Recorded Data on an Analog Computer" by *Ian Hay* (EAI Princeton Computation Center).

One of the many important properties of a correlation function is its ability to detect hidden periodicities. Problems are frequently encountered today where it is necessary to detect a signal which is "lost" in accompanying noise.

To illustrate, the author took a particular problem—determination of the azimuth of a signal which emanates from some unknown source at an arbitrary time. As the necessary basic concepts and definitions, in particular the correlation function, have been covered elsewhere*, emphasis was placed upon development and application of the technique, and circuitry necessary.

The detailed treatment is too complex for the *Newsletter*, but Fig. 10, which shows in block diagram form the circuitry required to instrument the correlation equation on a general-purpose analog computer, may be of interest.

The information from the receivers has been stored on magnetic tape, and must be fed through some input device to the computer, as $f_1(t)$ and $f_2(t)$. Following this the diagram is self-explanatory. One channel is fed through a delay and the other directly, to a multiplier, from which the product is averaged in an integrator circuit and the output recorded, as $R_{12}(\tau)$ against time, for a particular value of τ. Values of the correlation at other values of τ, are obtained by repeating the operation for a series of delays.

The Padé approximation method of simulating a pure delay was used, modified however to include only four attenuators instead of 12, as shown in Fig. 11.

As the frequency content on the magnetic tape was 0-10 cps. with delays of 0.1 second, the fourth-order approximation was quite satisfactory, being within 1° up to 7.5 radians phase shift.

Strict programming of the correlation equation would call for an integration over a finite time T seconds. This would be a laborious and time-consuming task on the computer, since it would in effect mean running for T seconds, stopping the computation, reading out results, and repeating the operation many times.

The application which Mr. Hay was considering was actually a data-reduction or processing problem, where the input is in continuous form. Consequently we should endeavor to obtain results in like man-

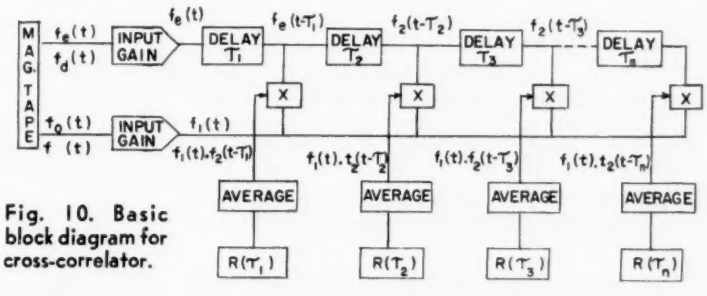

Fig. 10. Basic block diagram for cross-correlator.

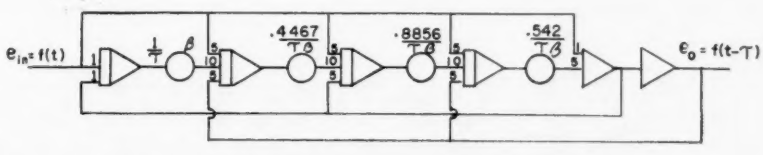

Fig. 11. Modified 4th-order Pade approximation—transport delay circuit.

*Y. W. Lee, "Application of Statistical Methods to communications Problems," Tech. Report #181, Research Lab. of Electronics, MIT.
Fenimore, "Correlation Analysis of Tape-Recorded Data," *Control Engineering*, Vol. 4, No. 8, p. 102, August 1957.
Bendat, *Principles and Applications of Random Noise Theory*, Wiley
Goldman, *Information Theory*, Prentice-Hall
Johnson, *Analog Computer Techniques*, McGraw-Hill.

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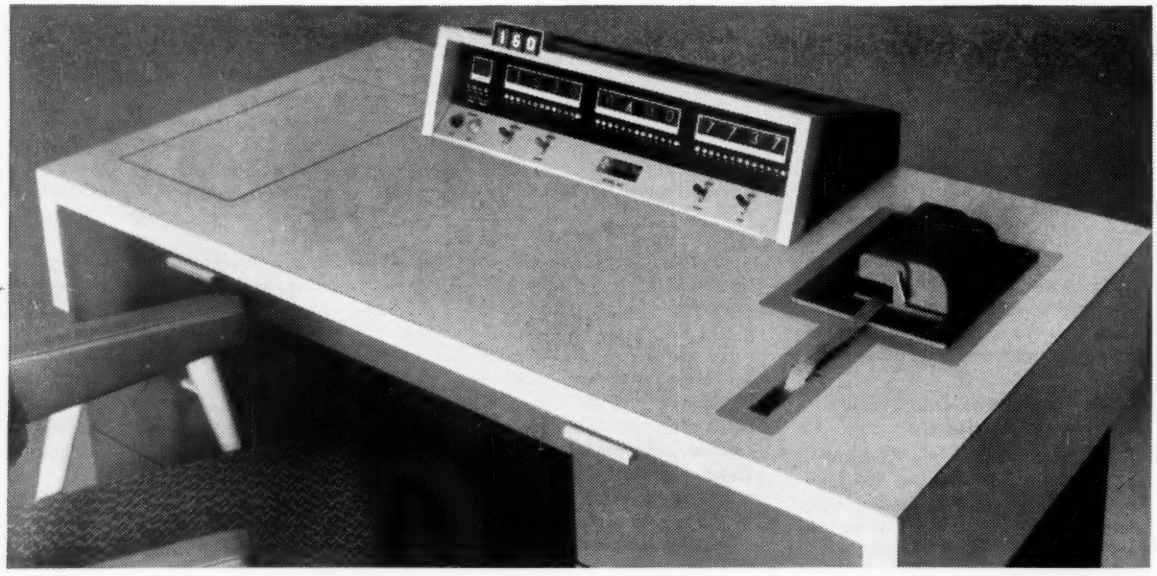

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1. MAGNETIC CORE STORAGE: 49,152 bits. Storage cycle time, 6.4 microseconds. Basic add time, 12.8 microseconds. Information read available 2.2 microseconds after start of cycle. Average execution time, 15 microseconds per instruction. 5 megacycle logic. Will handle input-output speeds of up to 65KC.

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3. PROGRAMMING: Repertoire of 62 instructions. Ease of programming features flexible addressing modes — no address, direct address, indirect address and relative address. Complete programming package includes 22-, 33-, 44-bit fixed point arithmetic, floating point, complex floating point, decimal, floating decimal, and algebraic compiler.

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ner. In other words, what is required is a continuous "moving window" effect, where the product $f_1(t)\ f_2(t-\tau)$ is rather filtered, or weighted in a continuous manner. This effect is obtained by using an exponential weighting function rather than a constant 1/T factor. A simple lag circuit (Fig. 12) gives this effect. The 1/T feedback pot now determines the weighting time or time constant, and can be set experimentally according to signal conditions.

The multiplication of $f_1(t)$ x $f_2(t-\tau)$ is an excellent application for electronic multipliers since the output of each multiplier has to be fed into a low-pass circuit which greatly attenuates any noise present.

During the discussion period a question concerned the merits of power-spectrum approach versus correlation approach, since the latter required delays which can be only approximated on the computer, as compared to the frequency approach which would require oscillators which can be made up accurately.

The author now answers that there are several points which may be considered: (a) An analog computer is a time-domain machine, and consequently is most useful in the time domain. Since, for this particular application, we are looking for a ratio of times to obtain an azimuth angle the direct (time) approach seems more logical.

(b) The frequency-domain approach was originally developed to get around inadequacies in math arising in the time-domain approach. However, it is not felt that for the application illustrated the correlation method is inadequate. Due to inherent inaccuracies in the problem statement extreme accuracy in any ensuing computation would be wasted.

(c) To obtain a power spectrum distribution, many runs or many channels would be required for comparing the input with standard frequencies, and since we are here processing approximately 1500 feet of tape every time we search for a signal, a multitude of results would be obtained, and would require analysis. With the "moving window" effect of the correlation technique, all results which do not show a signal can be immediately discarded. Whereas,

(d) It is not expected that the power-spectrum distribution of an input with signal would be detectable by inspection from the P.S.D. of an input without a signal. As a result it would probably be necessary to take a cross spectrum over a band and then perform a correlation analysis in order to determine the time delay.

TABLE 1—TENTATIVE SPECS OF SIMULAG GROUP 1.011

Minimum Time Delay: (V_c = 100 volts)	10 sec at N = 1000 1 sec at N = 100 0.1 sec at N = 10
Maximum Time Delay:	No limit since unit will store data indefinitely giving infinite time delay if $V_c = 0$.
Maximum Delay Resolution:	1024
Maximum Input Sampling Rate:	120 samples/sec
Static Amplitude Accuracy:	±.05% of full scale
Dynamic Amplitude Accuracy:	±5% at Max. Signal Freq. ±.5% at 1/3 Max. Signal Freq.
Delay Accuracy:	±.5% at minimum time delay (V_c = 100) $\pm .5\left(\frac{100}{V_c}\right)\%$ for other values of V_c
Delay Response Time:	Negligible compared to 120/sec sampling frequency.
Input Impedance, f(t) and V_c:	Greater than 100K ohms.
Output Signal f(t-T):	±10 volts full scale ±10 ma. max. (1000 ohms)
Input Power:	110V, 60 cps ±100 volt reference

It is obvious therefore that little would be gained in using cross-spectrum analysis techniques for this type of input signal.

Strong on Drum Simulag Group

John Strong (EAI, Long Branch, N. J.) next gave "Tentative Specifications—Magnetic Drum Simulag Group #1.011." The Simulag Group #1.011 was designed, John said, to meet the pressing need for accurate simulation of transport delay or dead time in analog computers or process control systems. For the first time,* the unique advantages of both digital and analog techniques are combined in a single hybrid component.

The system converts an analog input voltage, f(t), into 12-bit binary code and records it on a magnetic drum. After a time delay determined by a second input voltage, V_c, the signal is read off the drum and converted back to an analog voltage, f(t—T), at the output terminals. The delay time, T, is inversely proportional to V_c so that V_c is analogous to fluid velocity in the pipe line or process being simulated. Filters are used to smooth the steps in the output signal caused by the digitizing process. One Simulag Group is required for each variable being delayed, although additional channels are available to give different delays of the same variable. A block diagram is shown in Fig. 13; specs in Table 1.

John described the elements of the system in some detail as to function, but not as to method of operation.

Munson on Automatic Switching

John K. Munson (E. I. DuPont de Nemours, Wilmington, Delaware) on the subject "Automatic Switching Aids a Data-Fitting Problem" was the last speaker of the day.

He explained that a relatively common problem encountered in computer simulation is to determine numerical values of significant physical constants associated with a mathematical model of a process or piece of equipment. Often the only way that a correct set of constants can be established is to simulate the system with assumed values of the constants and compare the results of computa-

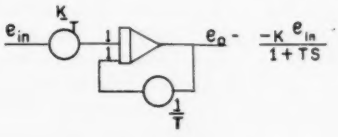

Fig. 12. Lag circuit.

*Anyone else question this?

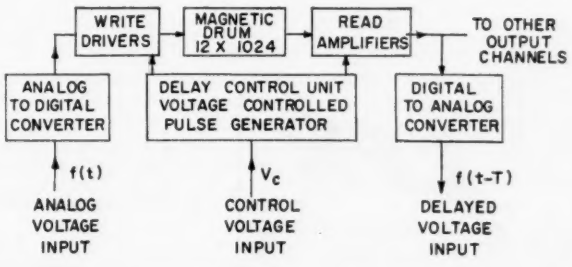

Fig. 13. Elements of Simulag Group 1.011.

The new LFE SM-2 converts digital computer language into a visual message . . . displays alpha-numeric characters, arbitrary or abstract symbols, schematic or logical drawings, graphs, charts and maps.

Twenty-one inch, flicker-free, display tube clearly displays up to 13,000 character messages, or 90 characters per square inch . . . is easily readable with ordinary office lighting . . . features self-contained storage. Brightness and storage are completely independent of the number of characters on any given page.

SM-2 is readily adaptable to data storage and retrieval systems as the on line output device. Typical of this application is LFE's commercially available RASTAD system.

Other applications include air traffic control, intelligence systems, inventory control, production control, process control monitoring, and other applications where information retrieval and display must be simultaneous. Additional specifications available by writing to Dept. 51.

LFE
COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.

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tion with laboratory or test data, adjusting constants and recomputing until a close fit is obtained.* Such calculations are helpful in establishing the validity of the mathematical model because a true constant should be invariant under varying external conditions. When numerical values have been determined, it then should be possible to explore different operating conditions on the model process.

Automatic switching circuits proved to be of considerable value in saving computation time and eliminating human error in the example described, in which kinetic constants for several simple chemical reactions were determined so that a more rational scale-up calculation could be made.

The chemical process used for illustration was the pyrolysis of a hydrocarbon gas to products of lower molecular weight and hydrogen.

These reactions

(1) A + Heat = B + H_2
(2) B + Heat = C + H_2

were studied in a packed bed reactor. Inlet gas of known composition was fed into a packed tube electrically heated to a high temperature. The outlet gas, a mixture of A, B, C, and hydrogen, was analyzed for composition.

As this problem is illustrative of a type often encountered in industry, and as the solution was explained lucidly enough to be of interest and possible help to others we wish, as in the case of some of the other meeting papers, that we could give it here verbatim. However, it will have to suffice to say that the practical difficulties in computation resulted from the fact that each of the points determined involved 14 analog calculations, each of which involved a different combination of values for the operating conditions of pressure, heating rate, gas flow, inlet gas composition. To save the time and avoid the errors involved in resetting pots, it was decided to store these parameters and switch them into the circuits as needed. Twenty-six potentiometers and five diode function generators were used for this purpose. Computer operation was automatic in that, when put into "compute," the computer would calculate and reset 14 times as controlled by auxiliary relay circuitry, also calculating and storing the individual and cumulative error criteria. Parameter substitutions were made between each of these 14 runs by a standard stepping switch, with eight decks of 15 positions each. The time scale of this problem was such that each set of 14 runs took about 3½ minutes.

Mr. Munson explained the automatic operation and switching circuitry and the sampling circuits, and concluded that automatic computer operation and parameter switching is feasible using only one inexpensive stepping switch in addition to the standard analog computer hardware. Application of these techniques to a data-fitting problem saved many hours of potentiometer changes, and human error was largely eliminated.*

*"Post-flight Simulation" in our racket.—Ed.

WESTERN S/C MEETING OF 18 NOV. ON STATISTICAL STUDIES

The Western Simulation Council met at Douglas El Segundo (California) on 18 November 1959 to hear talks, participate in discussion of the use of analog computers for statistical studies, and inspect the local Douglas computing and simulating facilities.

Ironically, because he was unable to attend, your Ed has less info on this meeting of his own Council than he has from many held across the country. However, two of the three speakers were kind enough to furnish us with the abstracts which follow:

"Spectral Characterization of Control System Nonlinearities" by R. B. McGhee (Hughes Aircraft Co., Culver City, Calif.)

Control-system feedback elements are subject to statistical variation from their desired characteristics due to manufacturing tolerances. For most feedback elements, this variation takes the form of a random nonlinear function of the input to the element. Analysis of the effects of such feedback errors is exceedingly difficult because the control system affected must be described by a random nonlinear differential equation. It is proposed that this difficulty be surmounted by computer simulation.

For purposes of simulation, a power spectrum is developed for the ensemble of feedback error functions. This power spectrum then is used to synthesize artificial nonlinearities in the simulation of the control system. By simulating groups of components with different statistical properties, production specifications can be generated based on parameters borrowed from noise theory such as power spectral density, noise bandwidth, rms error, etc.

This development is followed by two experimental examples which illustrate the application of the method and display the concept of bandwidth as applied to a feedback nonlinearity. It is shown that, in some situations, linearizing approximations permit analytic determination of the effects of random feedback error. In other problems, the utilization of power spectra permits the normalization of computer results.

This paper was to be published in the December 1959 edition of the *IRE Transactions on Automatic Control.*

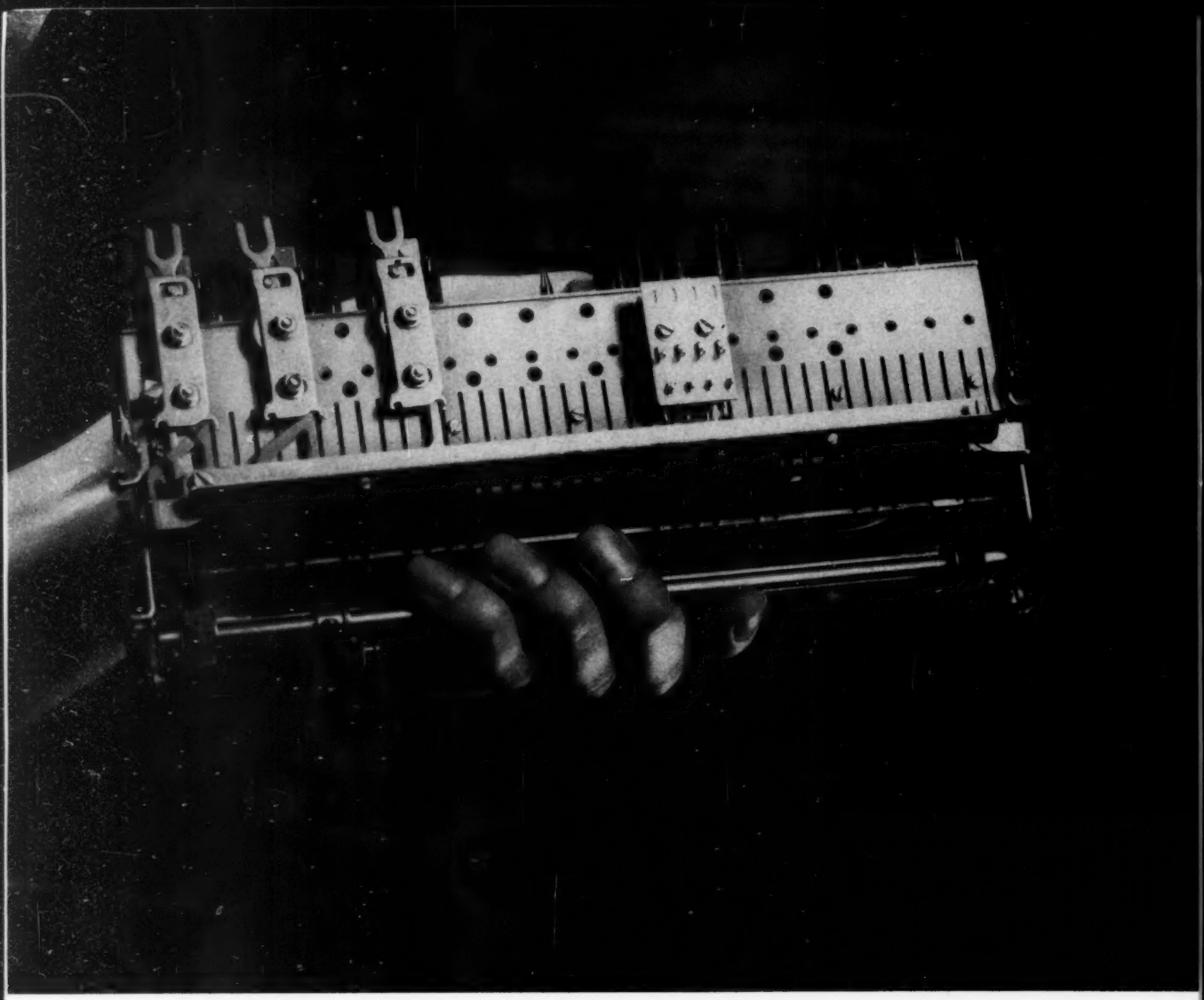
"Determination of Optimum Production Tolerances by Analog Simulation" by R. B. McGhee and A. Levine (Hughes Aircraft)

This paper extends the role of analog simulation in the preliminary design of control systems to include optimization of manufacturing tolerances as well as the more common optimization of parameter values. The proposed simulation technique involves random variation of parameters by noise generators along with automatic computation of a performance index. The simulation results in a performance function in terms of the production tolerances assigned to the system parameters as well as the nominal values selected.

When the performance function is considered together with a cost function also depending on parameter tolerances, an optimum tolerance assignment can be made by minimizing cost for a fixed level of performance or maximizing performance for a fixed cost.

The description of the method is followed by an experimental example

*Commendable in this instance no doubt, but it sure could make life dull, couldn't it?—Ed.



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Built into Teletype Model 28 page printers is a control device called the Stunt Box. The function of this unique component is to provide extra control facilities for both local and remote operations. Thus—in addition to transmitting, receiving and recording messages and data—the page printer can be used for a variety of switching, remote control and selective calling tasks.

The Stunt Box reduces costs by simplifying equipment needs and systems arrangements. It is the Big Plus—the extra value in Teletype Model 28 page printers and automatic send-receive sets.

Teletype Corporation manufactures this equipment for the Bell System and others who require the finest in data communications equipment.

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which refutes some common opinions and practices relating to production tolerance assignments. It is shown that an *a priori* estimation of the form of the functional dependence of performance on parameter values can lead to serious engineering errors in the assignment of tolerances.

The design of statistical experiments of this type are discussed in the context of the experimental example. It is pointed out that high-speed repetitive analog computation is required in a problem of practical complexity. Special simulation considerations such as automatic data processing, multiplexing of noise generators, etc. also are discussed.

This paper will be published in the *Proceedings of the Eastern Joint Computer Conference*, 1959.

"A Stochastic Method of Solving Partial Differential Equations Using an Analog Computer" by Kuei Chuang, (U. of Mich.), L. F. Kazda (U. of Mich.); T. G. Windeknecht, (Space Technology Labs—the speaker)

This paper describes an analog-computer method for solving a generalized class of two-dimensional boundary-value problems of the Dirichlet Type using a small number of operational amplifiers. The method involves simulation of a random process which generates the solution of the boundary-value problem, a technique commonly designated as the "*Monte Carlo Method*." In this case, the random process becomes a tool for the numerical analysis of the partial differential equation.

A number of one- and two-dimensional boundary-value problems whose analytical solutions are known have been solved using the method. A comparison of the experimental and analytical solutions corroborates the validity of the method.

This paper has been accepted for publication in the proceedings of the First International Congress of IFAC (International Federation on Automatic Control) to be held in Moscow in the summer of 1960.

Of this paper one of your Ed's colleagues at Astro, Allan Wilson, says in part:

"This excellent paper reported a new method for solving a certain type of differential equations. The work was supervised by Professor Chuang at the University of Michigan, with runs performed at the Willow Run Laboratory at Ypsilanti. The method is new in the sense that apparently it is the first time it has been applied to analog computers, although the same principle has been used on digital computers.

"The method is applicable to the solution of the linear, homogeneous second-order partial differential equation in two independent variables. The solution may be found inside a single closed curve, with the function specified on this curve as a boundary condition. (This is the so-called 'Dirichlet Problem' of Type 1). Solution is found successively at desired points within the curve by a random walk process to the boundary and by making use of the fact that the limit of a certain statistically-generated function converges to the solution of the differential equation. The random walk is simulated by use of a noise generator and is terminated at the boundary by a sort of photo-former method. Certain coefficients of the differential equation are related to the spectral density of the noise source.

"Convincing experimental data were shown for examples of LaPlace's equation and a diffusion equation. Three hundred samples per point were generated within 15 minutes on a non-repetitive computer. The method is slow, but has the great advantage of not requiring a large system. Economically, it appears to be able to compete with digital methods for a 'quick and dirty' estimate in cases where the boundary condition is not symmetric or otherwise simple. The speaker was optimistic about further developments."

Tour of Douglas Facility

We are indebted to *Don Bonsteel* for the description of the tour of the local facilities which follows:

The direct analog computer consists of 53 decade inductors, 53 transformers, 76 decade capacitors and 76 decade resistors. These elements are arranged with a control desk at either end, permitting operation from two points. Eighty-five d-c amplifiers provide the necessary active elements for dynamic studies. Nonlinear equipment includes eight high-speed electronic multipliers, two photoformers, and a number of Quadratrons.*

The group saw a demonstration of the Quadratron's versatility as the device was used for squaring and for generating a sine function. A modulator-demodulator using Quadratrons for multiplication was also on exhibit.

*Available from Douglas.

The differential analyzer was inspected next. It consists of 286 operational amplifiers, 28 servo multipliers, 12 servo resolvers, 24 chart recorders, 6 diode function generators, and a 12-channel tape recorder. Most of the computer problems are solved in real time. Many of them require the tie-in of control system hardware which is located in the Controls Laboratory. Interconnection is accomplished by cabling between the computer and 9 floor-stations, located in the laboratory area.

The maintenance test rack was described. It consists of rack-mounted spare power supplies, computer amplifiers, servos and test gear. The test equipment permits computer components to be checked out while in operating condition without disturbing the main computer. The maintenance test rack is also useful as a small auxiliary computer and as a supplement to breadboard development of electronic components.

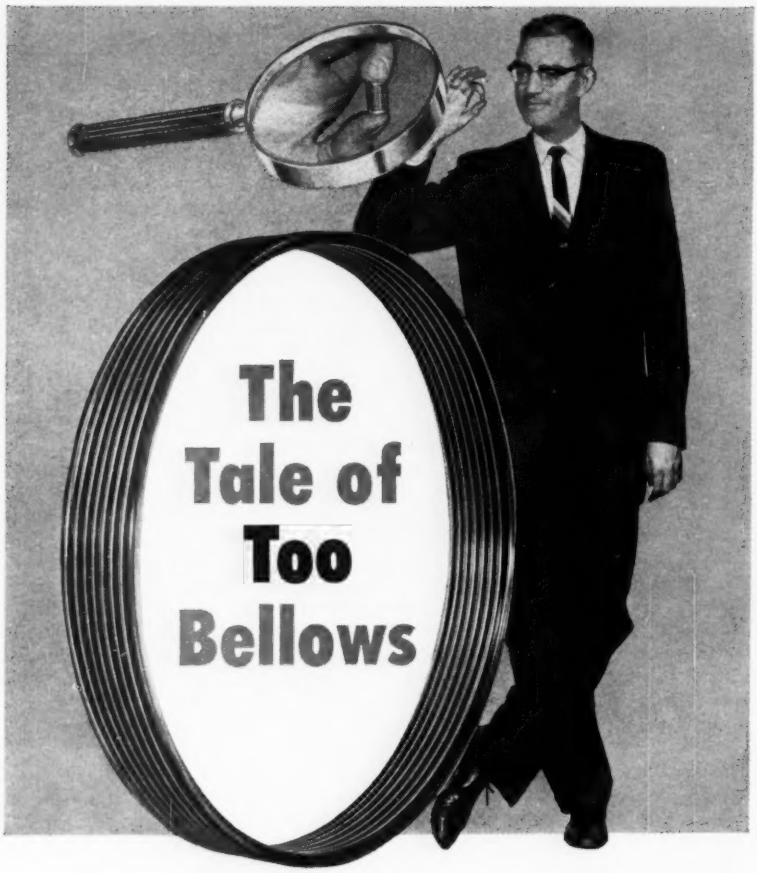
Two of the several active computer problems were demonstrated. One was the study of an automatic flight control system for one of the Douglas-built Navy aircraft. A control-system simulator consisting of pilot stick and rudder pedals, cables, linkages and hydraulic surface actuators was driven by autopilot servos. These servos received autopilot commands. The surface positions were measured electrically and the surface signals were used to command the simulated aerodynamic equations.

The Army-Navy Integrated Instrument Presentation display also was demonstrated. The display consists of one TV tube and one C-R tube which present the pilot with all pertinent flight path and navigational information in a form which seems most natural and easiest to interpret. One display presents flight-path information in a manner which appears to the observer as though he were flying along the desired flight path. The other consists of an aircraft symbol which traverses a map of the terrain over which the pilot is flying. Observers were able to compare the ease of following a prescribed course using the proposed display with the difficulty of flying the same course with conventional instruments.

Must stop now—I don't want to alienate anyone with reader's cramp.*

The end—Let Us Rejoice!

*Symptoms: Loud snoring followed by a vague awareness of a new pain in the neck.



The job is too big for a bellows, one man said . . . and another job was too small for a bellows.

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MODERATE-PRICE COMPUTER

New Honeywell 400 Computer handles up to 6,000 additions or subtractions/sec which is up to 10 times as fast as with existing models in its price range. The system also has the fastest printing and sorting speeds and uses the fastest and most reliable

magnetic tapes. Information is completely compatible between the new Honeywell 400 and the type-800 tapes. The central processor functions at an internal speed of up to 6,000 operations/sec (such as additions or subtractions). The core memory capacity is 1,024 words of 48 bits each. The transfer rate of information to or from the high-speed magnetic tapes is 64,000 characters or 96,000 decimal digits/sec. Orthotronic control automatically detects and corrects any errors in or damage to information recorded on the magnetic tapes. The high-speed printer operates at 900 lines/min; the card reader handles 650 cards/min. In addition to the standard system of a central processor, four tape drives, a printer and a card reader, one or two additional tape mechanisms can be added at any time. One standard or high-speed card punch can be added to the system as optional equipment. The basic model (with a powerful central processor, four high-speed magnetic tape units, a high-speed printer, and a card reader) will rent for $8,660/month.—*Datamatic Div., Minneapolis-Honeywell Regulator Co., Newton Highland 61, Mass.*

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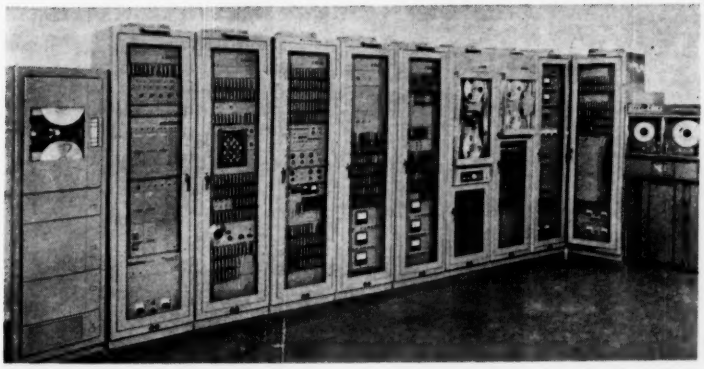
COMPUTER TRANSLATOR



New ZA-100 Computer Language Translator system performs 13 electronic data translations between an IBM 704 and a Remington Rand Univac, to interchange mathematical data or to process raw scientific data.—*Electronic Engineering Co., of Calif., 1601 East Chestnut Ave., Santa Ana, Calif.*

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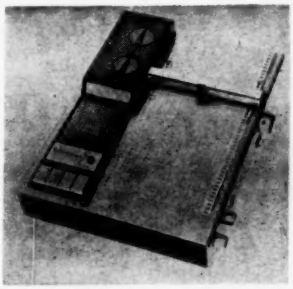
PORTABLE RECORDER

New portable Potentiometric Strip-Chart Recorder features push-button operation, and a nylon tape pen drive which assures positive connection between pen and slide wire, and permits the use of over-size strip charts or of circular charts. It monitors d-c signals in the 10-100 mv range and provides 5" pen travel and repeatability of better than 0.35%. Pen response is 1.0 sec full-scale.—*Beckman Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.*



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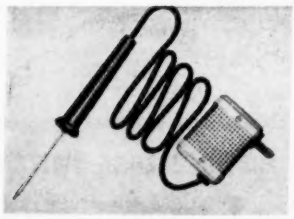

New Type T-12-XF Transformer-type Electric Soldering Iron features extreme flexibility and line-voltage isolation eliminating any chance of current-leakage or grounding. Tip element of Armco ingot iron has 17-watt input from 12-v transformer output. Form 220-CP gives details.—*American Electrical Heater Co., 6110 Cass Ave., Detroit 2, Mich.*

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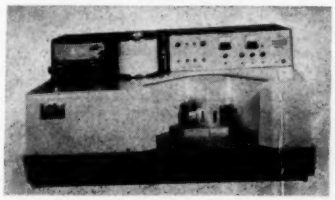
New infrared Double-Beam Spectrophotometer, Model NK-1, is able to scan 2-16 μ in 4 min or less instead of the 14 min previously required, with no loss of resolution or accuracy. This is due to the new automatic scan control and continuously accelerated scan speeds. Available attachments now allow wavelengths from 0.2μ to 38μ.—*Baird-Atomic, Spectrochemical Div., Cambridge 38, Mass.*



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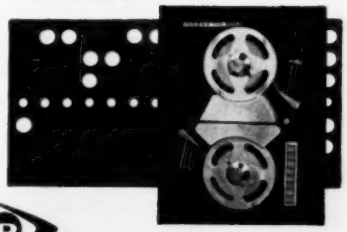

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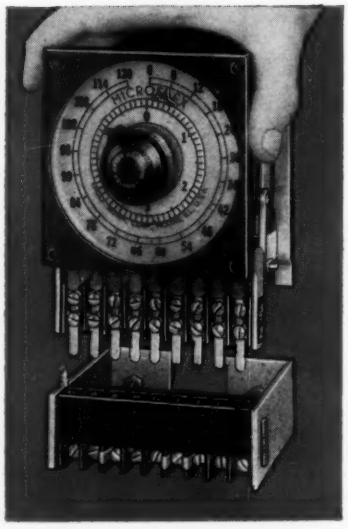

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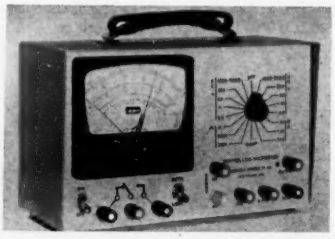

relay has 5-amp contacts that enable it to handle almost any audible or visual alarm power relays, servo motors, etc. Ranges: D-c voltage—2.5, 10, 50, 250 and 1000-5000 v; a-c voltage—2.5, 10, 50, 250 and 1000-5000 v; current—0/100 μamp; 0/10 mamp; 0/100 mamp; 0/10 amp. resistance—to 20 Mohms in three scales with center scale values of 12, 1200, and 120,000 ohms.—*Assembly Products, Inc., Chesterland, Ohio.*

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CLOUD HEIGHT RECORDERS

New Cloud Height Rotating Beam Ceilometer Recorder provides instant graphic recordings of cloud ceilings, discontinuities, ice crystal formations and other atmospheric phenomena. Operating on received signals from a rotating beam ceilometer system, a beam of light scans the sky from the horizon through the vertical position. Light reflected from the cloud ceiling is detected by an electronic eye and recorded on Alfax electrosensitive paper in a tone shade proportional to the signal strength. Specification sheet contains details.—*Alden Electronic & Impulse Recording Equipment Co., Inc., Alden Research Center, Westboro, Mass.*

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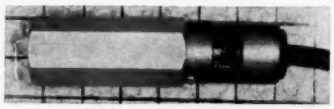
MINI PRESSURE SWITCH

New Model 760 Miniature Pressure Switch for operating pressures from 25 to 1000 psig features piston-type operation, adjustable operating pres-



sure (Model 760-A: to 250 psig, Model 760-B: 200 to 1000 psig), fixed differential, and operation with any media. Available in steel and aluminum, switch is UL-approved, rated 5 amp 240 v SPDT. Bulletin PS-76 contains details.—*Alloy Bellows, Inc.*, 18125 *Roseland Rd., Cleveland* 12, *Ohio.*

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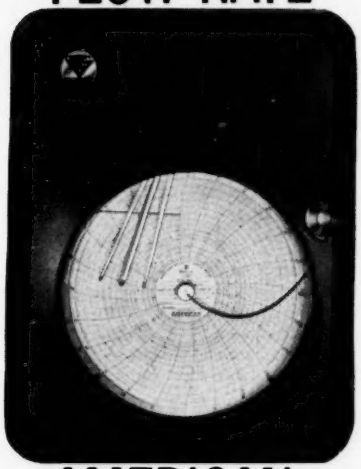
PRECISION MEASUREMENT AT ANY FLOW RATE



AMERICAN-WESTCOTT A-88

ORIFICE METERS

Versatile American® Series A-88 mercury-type orifice meters meet the toughest flow measurement requirements – working pressures to 5,000 psi – interchangeable 10, 20, 50, 100 and 200-inch ranges. Recording meters may be equipped with 0-150° F. standard temperature element. Integrating meters integrate static and differential pressure, providing totalized flow indications. Telemetering equipped meters transmit integrated indications to remote locations.

- Manometer body easily cleaned — does not affect calibration.
- Tamper-proof calibration — simple, positive adjustment of float lever arm length.
- Interchangeable ranges — no manifold piping changes.
- Teflon-packed stuffing box is pressure tight, nearly frictionless, never needs lubrication.
- Teflon-packed pulsation dampener externally adjustable under full line pressure.
- Check valves give positive shut-off for over-range protection.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)

General Offices: Philadelphia 16, Pa.
Sales offices in principal cities

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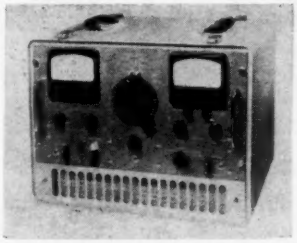
DELAY MEASURING SET

New compact Transmission and Delay Measuring Set Type 453-A measures attenuation and relative delay characteristics of transmission lines, lumped constant networks and other

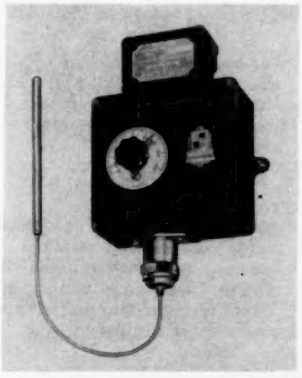


transmission systems, having characteristic impedances of 600 ohms, over a carrier frequency range from 500 cps to 50 kc. Overall precision and accuracy of delay is ±5 μsec. Measurement data are obtained from a direct-reading meter which has three sensitivities; 0-8, 0-2.0, 0-0.2 msec full scale. Unit is designed for mounting on a standard 19" rack.—*Acton Labs., Inc., 533 Main St., Acton, Mass.*

CIRCLE 217 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER

New explosion-proof non-indicating Temperature Controller, Model GVS, incorporates in a sealed enclosure a snap-acting switch to control



an electric circuit actuating valves, solenoids, motors, heating elements, or other appliances. Thermal element is mercury filled.—*Partlow Corp., 534 Campion Rd,. New Hartford, N. Y.*

CIRCLE 218 ON READER-SERVICE CARD

STRESS COMPUTER

New Stress Computer, for producing a textbook-definition stress-strain-curve recording for Riehle recorders, converts the load-axis pen travel on the recorder to a stress value after the factors of original specimen area and approximate strength value have been introduced. Available as a factory-installation unit only.—*Riehle Testing Machines, Div. of American Machine and Metals, Inc., East Moline, Ill.*

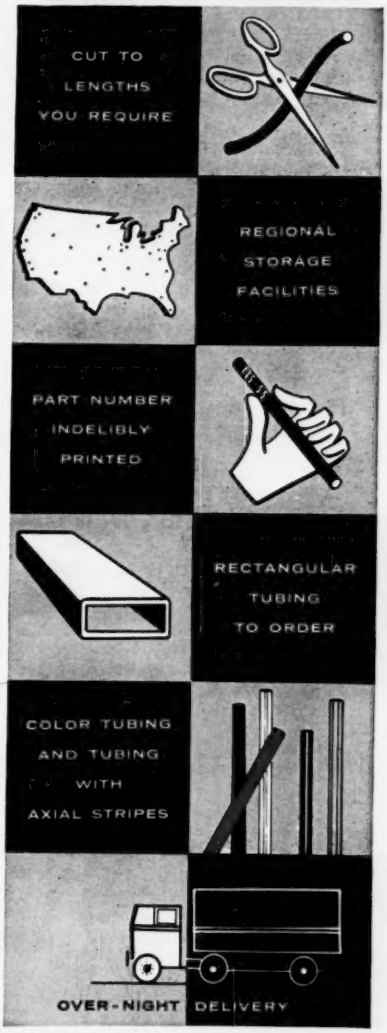
CIRCLE 219 ON READER-SERVICE CARD

offers the excellent electrical advantages of

TEFLON*

plus these important

SERVICES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REGIONAL STORAGE FACILITIES
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OVER-NIGHT DELIVERY

NOTE: PF TEFLON* advantages: good dielectric strength: (500 to 1000 volts/mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electrical properties with temperature (−25°C to +250°C) or frequency (60 cycles to 100 mc); zero moisture absorption; unaffected by any commercial chemical.

WRITE, WIRE OR CALL:

PENNSYLVANIA FLUOROCARBON COMPANY, INC.
1115 N. 38th Street, Philadelphia 4, Penna.
EVergreen 6-0603 · TWX PH 252

*TEFLON—du Pont trade name for tetrafluoroethylene resin

CIRCLE 90 ON READER-SERVICE CARD

DEKORON ARMORED INSTRUMENT HARNESS

4+4=16

TUBE MATERIALS + TUBE CONSTRUCTIONS = DIFFERENT TYPES

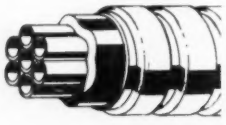
Yes, *four* different core tubing materials (copper, aluminum, polyethylene, nylon) combined with *four* distinct types of armoring give you *sixteen* different types of Dekoron Armored Instrument Harness from which to choose.

Designed specifically for instrument harness application, special Moore-Loc armor construction has almost twice the pull-apart resistance of ordinary armoring . . . has cord packing for extra resistance to moisture and fume penetration.

There's at least one best type of Dekoron for your installation. We help *you* select it; we're unbiased because we make all types. Now go Dekoron 100% for all your tubing needs. Think of Dekoron first . . . to last. That's *Dekoron—America's Premier Line of Armored Instrument Harness.* A-583A

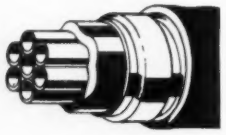
CONSTRUCTIONS

TYPE VA



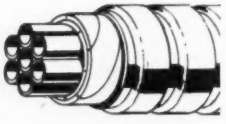
For Impact and Corrosion Resistance. Core tubes with vinyl sheath covered with Moore-Loc modified-square-lock construction armor with cord packing.

TYPE VAV



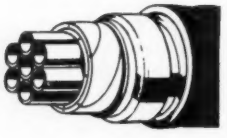
For Impact and Maximum Corrosion Resistance. Same construction as Type VA (*above*) but with outer vinyl sheath. 24-gauge galvanized steel armor gives maximum pull-apart and impact resistance.

TYPE A



For Impact Resistance in Dry Locations. Core tubes are wrapped in vinyl-impregnated insulating tape. Tape insulates and cushions core tubes inside metal armor.

TYPE AV



For Corrosion and Impact Resistance. Same construction as Type A (*above*) but with outer vinyl sheath. All four constructions available with metal or plastic core tubes.

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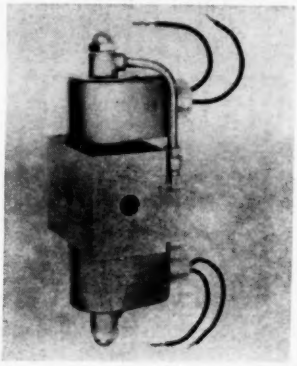
SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

CIRCLE 91 ON READER-SERVICE CARD

SOLENOID VALVES

New 3-position, 4-way dual Solenoid Valves are instantaneous in operation and utilize only two moving pilot cores and four flexing diaphragms. Available with ¼" or ⅜" pipe con-

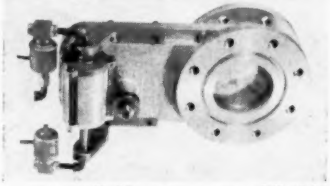


nections in a rugged brass bar-stock body and with poppet type seats. Suitable for handling air, water, and oil from 10 to 250 psig on a-c or d-c voltages. Bulletin 8347 (Form No. V5073R1) gives details.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 220 ON READER-SERVICE CARD

REMOTE VALVE ACTUATOR

New air-operated Controller for an established line of high-vacuum gate valves, effecting 180° of rotation of a valve stem, features great space-saving compactness and very fast operation. Closing time is better than 0.2



sec at available pressures. Working on the rack-and-pinion principle, the piston is fixed and the cylinder carries the rack. Air moves the cylinder to turn the pinion gear mounted on the valve stem. A unique design permits manual operation in the event of power failure (where systems are based on electrically-operated solenoid valves), or in the event of air pressure failure.—*Vacuum Research Co., 420 Market St., San Francisco, Calif.*

CIRCLE 221 ON READER-SERVICE CARD

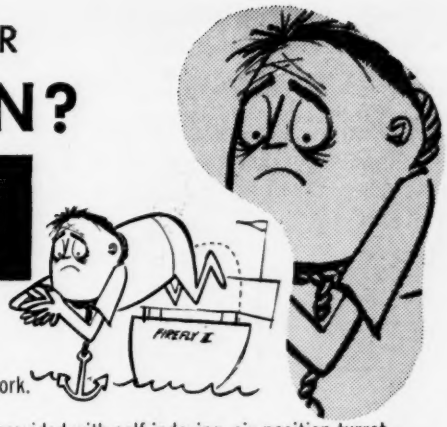
ANALYTICAL BALANCE

New Analytical Balance, Model Vivancil 357, made in France, is an ultra-rapid single-pan constant-load balance, air-damped with sharp projection reading. Sensitivity is constant regardless of the mass placed on the pan. Capacity is 200 gm; 0.1 mg equals ½ scale division. Bulletin gives details.—*Epic, Inc., 150 Nassau St., New York 38, N. Y.*

CIRCLE 222 ON READER-SERVICE CARD

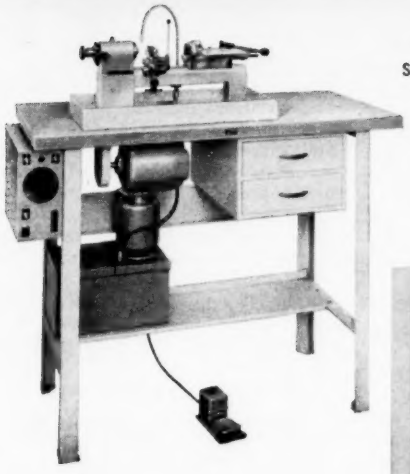
ARE YOU PROPERLY GEARED FOR

MINIATURIZATION?



LEVIN® TURRET LATHES

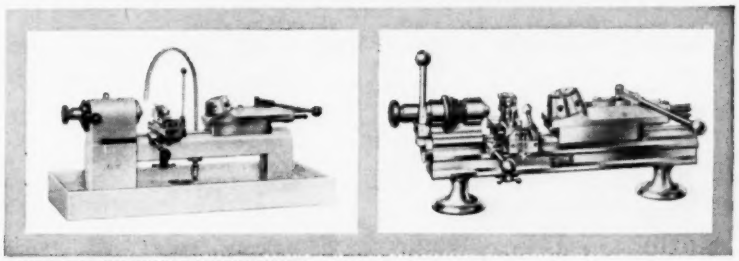
PRODUCE SMALL INSTRUMENT PARTS BETTER



A complete Turret Lathe for small parts. Particularly useful for second operation work. Maximum collet capacity 5/16". Standard models provided with self indexing, six position turret, collet closer, double tool cross slide and variable speed control.

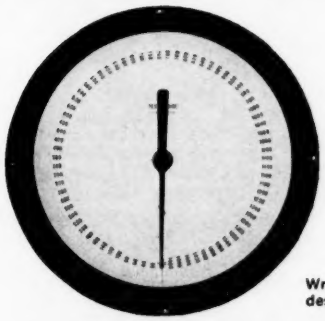
For full details of Turret Lathes and other Instrument Lathes send for catalog T.

Louis Levin & Son, Inc., 3610 So. Broadway, Los Angeles 7, Calif.



CIRCLE 92 ON READER-SERVICE CARD

PRECISION TEST GAUGES



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Consider These Advantages:

- 360° Calibration provides 25% greater scale length.
- Saves over 115 square inches of panel space.
- Ni-Span C Bourdon tube is temperature stable.
- Tube tip bleed is standard equipment.
- .15% full scale accuracy.
- Movement calibrated to dial, uniform increments.
- Capacities to 15,000 psi.

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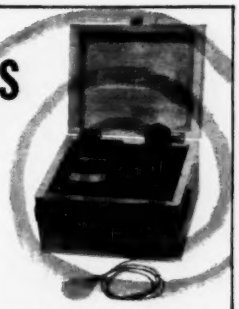
Precision Pressure Instruments— Testing — Weighing — Load and Force Measurement

CIRCLE 93 ON READER-SERVICE CARD

NEW N.I.L.

HEAT-FLOW DISKS MEASURE HEAT LOSS DIRECTLY



For measurement and control, the NIL disks sense the rate of heat-flow (gain or loss) directly. They have an electrical output proportional to the rate of flow of heat through a surface.

HGF-2 Monitor with HF-2 Disk

HERE ARE SOME TYPICAL USES:

1. Anticipating temperature changes for control system.
*2. Surveying for heat-loss areas in ducts and pipes.
*3. Checking efficiency of heat exchangers.
4. Operating alarm systems, winter or summer.
5. Direct recording in engineering tests.

NIL heat-flow disks are inexpensive, reliable, rugged, lightweight, and easy to install.

SELECT THE ONE YOU NEED:

CAT. NO.	OUTPUT MICROVOLTS per BTU Ft.² Hr.	DIAM. IN.
HF-1	2.5	0.4
HF-2	250	2.0
HF-3	714	4.3

*The HFG-1B or HFG-2 Heat-Flow Monitors using the disks are designed for this function.

FREE: Illustrated Data Bulletin

NATIONAL INSTRUMENT LABORATORIES, INC.

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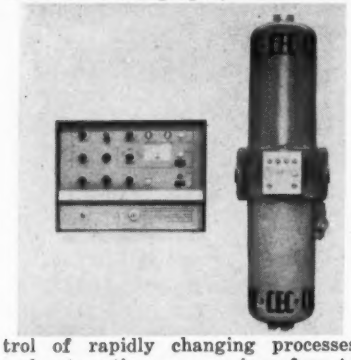
CIRCLE 94 ON READER-SERVICE CARD

PROCESS CHROMATOGRAPH

New Type 26-212 Process Chromatograph which makes analyses of liquids, gases, or vapors in 1/20th to 1/50th the time required by conventional chromatographs, affords con-

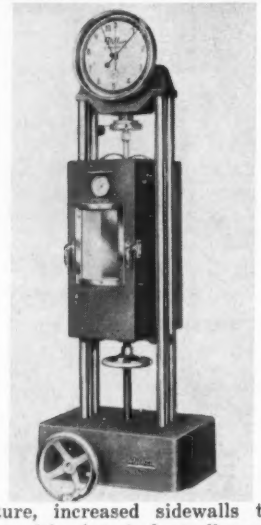


trol of rapidly changing processes and automatic programming of up to eight streams. Consists of two separate units: (1) the analyzer, which is housed in an explosion-proof housing for on-stream installation in hazardous areas; and (2) the control unit, which can be located on a control panel as far as 500 ft from the analyzer.—*Consolidated Electrodynamics Corp.*, 360 *Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 223 ON READER-SERVICE CARD

CONTROLLED-TEMP CABINET

New improved Controlled-temperature Cabinet for universal testing machines features more uniform tem-



perature, increased sidewalls thickness, positive interlock at all seams or joints, increased electric heating element surface, improved thermostat, and a larger-size observation window. —*W. C. Dillon & Co., Inc.*, 14620 *Keswick St., Van Nuys, Calif.*

CIRCLE 224 ON READER-SERVICE CARD

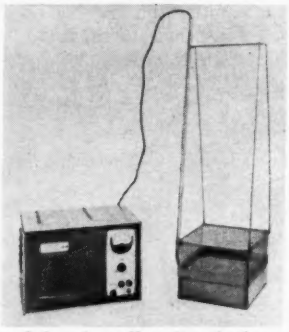
VOLTAGE RECORDER

New narrow-range a-c Voltage Recorder provides a continuous record of voltage fluctuations between 110 and 130 v on a 10¾" calibrated scale and strip-chart. Accuracy is ±0.25% of mid-scale voltage. The recorder uses the stable voltage characteristics of a silicon diode to compare forward and reverse half-cycles of the input voltage.—*General Electric Co., Schenectady 5, N. Y.*

CIRCLE 393 ON READER-SERVICE CARD

ULTRASONIC BASKET

New stainless-steel Circosonic Basket, Model CB125, has barium titanate transducers sealed in the bottom. Connected to the Circosonic generator, Model PG125, the basket can be sub-

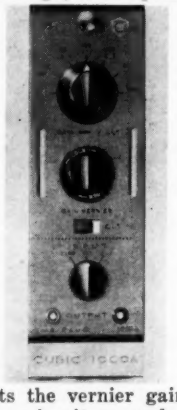


merged in virtually all solutions for use as an ultrasonic cleaner. Operating frequency is 40kc. Overall dimensions are: 9½" lg x 9½" w x 33" h. The generator has an output of 125w av., 250 w peak; power output is 500 w, 115 v/60cps/1 ph.—*Circo Ultrasonic Corp.*, 51 *Terminal Ave., Clark, N. J.*

CIRCLE 225 ON READER-SERVICE CARD

WIDEBAND AMPLIFIERS

New Model 1000A DC-Wideband Amplifier series offers fixed gain between 10 and 1000 with Cubiplugs, plug-in units which determine specific gain range; a two-position slide



switch cuts the vernier gain control out of the circuitry; and a three-position input selection switch which shorts the amplifier input, or isolates the source and introduces a precision 10-mv d-c voltage source. Bulletin 100_D contains details.—*Cubic Corp.*, 5575 *Kearny Villa Rd., San Diego 11, Calif.*

CIRCLE 226 ON READER-SERVICE CARD

D-C VOLTAGE STANDARD

New Model STV is an extremely accurate and stable Reference Source for use with null-balance devices such as potentiometers and other infinite-

impedance comparators. It is claimed to be at least equivalent in accuracy to the best unsaturated standard cells and superior in almost all other respects to both saturated and unsaturated types. Essentially a zero-current-drain instrument, it can be operated without damage into any impedance. Accuracy is ±0.01% of nominal output; stability is ±0.005% of actual output for 100-to-125-v input. Bulletin gives details.—*Sensitive Research Instrument Corp.*, 310 *Main St., New Rochelle, N. Y.*

CIRCLE 227 ON READER-SERVICE CARD

MODULAR TRANSIT CASE

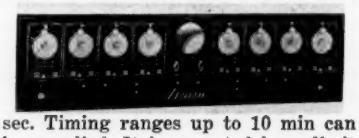
New Unistruc Transit Case is a fully-bonded structure in which sandwich panels are joined to a frame. Using

alloy corner castings, the modular unit has increased strength-to-weight ratio and meets MIL-T-945/A, MIL-T-4734, MIL-T-21200, and MIL-C-4150/E specs. Sealing is by "O" ring gasket.—*Skydyne, Inc., River Rd., Port Jervis, N. Y.*

CIRCLE 228 ON READER-SERVICE CARD

MULTI-UNIT RESET TIMER

New multi-unit Reset Timer Panel, Model 8AZC, provides automatic control of eight sequential operations. Each timer is calibrated from 0 to 60

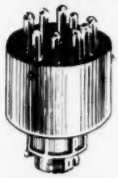


sec. Timing ranges up to 10 min can be supplied. It is operated by a limit switch and is fully automatic. The timer is also available as Model M2ZC for dual timing operations and Model MZC for single operations.—*Zenith Electric Co., Dept. IA-5*, 152 *West Walton St., Chicago 10, Ill.*

CIRCLE 229 ON READER-SERVICE CARD

connectors

Lighter weight, smaller packaging, rugged construction, plus the ability to perform dependably under extreme environmental conditions, are all-important features of Harco thermocouple connectors. A perfect material match to other thermocouple circuit elements, Harco connectors successfully avoid signal interpretation errors and loss.



High temperature resistant connectors . . . quick disconnect sockets and plugs for all standard calibrations . . . a full range of shell styles and contact arrangements.

Harco designs special connectors to meet your individual needs.

Write today for free technical literature and the name of your local Harco Factory Representative.

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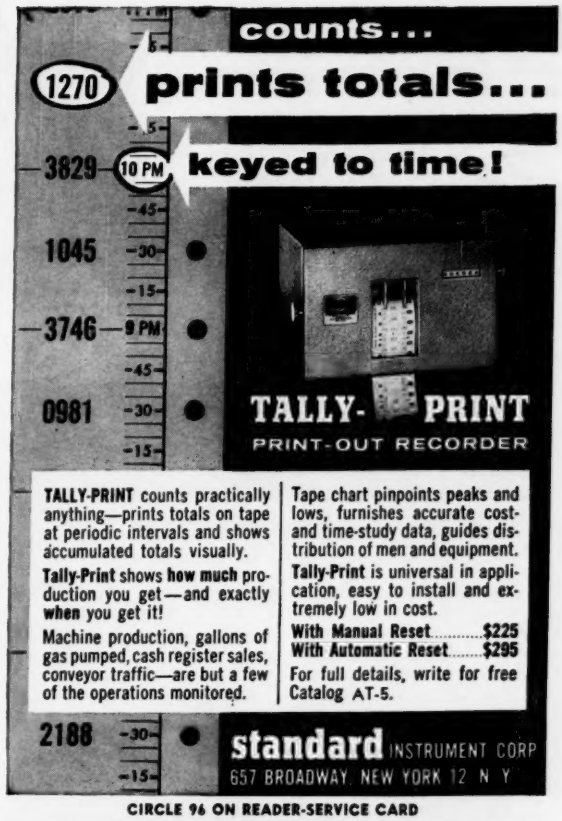
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prints totals...
3829
10 PM
keyed to time!
1045
3746
9 PM
0981
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AC CONTROLLER
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Complete, F.O.B., Las Vegas, Nevada **$84**

2T60 ELECTRONIC CONTROLLER with matching 1/50 H. P. DC MOTOR

SPECIFICATIONS

• Thyraton tube operated controller gives stepless operation • Input: 110-120 V., 60 cy. single phase • Output: 0-120 V., 200 ma. DC to armature • 1/50 H.P. ball bearing, right angle, gear head, shunt wound, DC motor • Reversible • Armature speed 0 to 4000 R.P.M. • Armature shaft is extended • Motors in gear ratios: 6, 18, 30, 36, 60, 100, 300, 540, and 1120:1 in stock.

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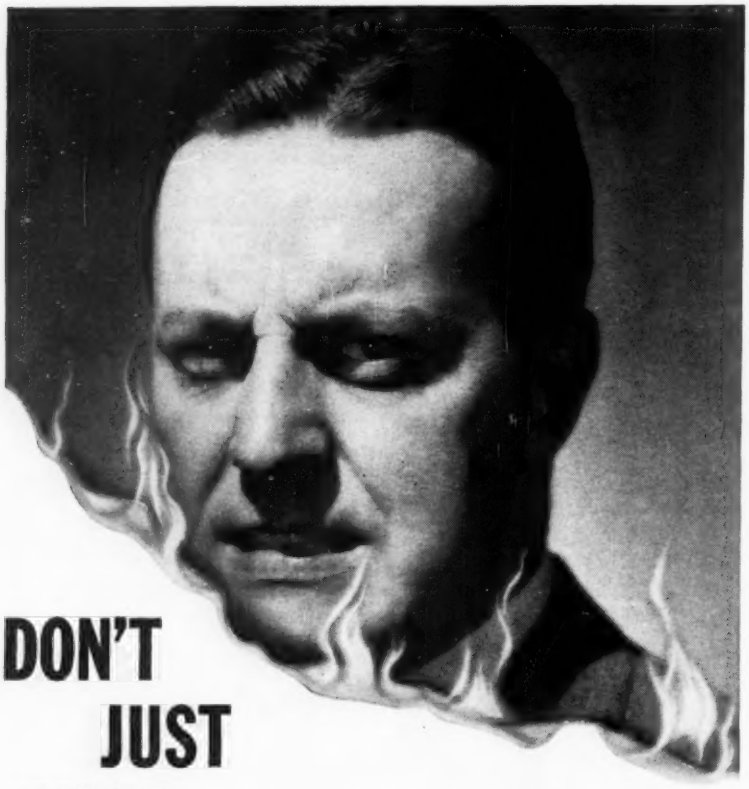
CIRCLE 98 ON READER-SERVICE CARD

FURNACE GAS ANALYZER

New Model 184B Furnace Atmosphere Analyzer affords completely automatic analysis of selected components in furnace atmosphere, flue gases, and controlled atmosphere. The process gas-chromatography instrument performs an automatic four-component analytical cycle every 10 min. Applications include heat treat furnaces, endothermic gas generators, kilns and other combustion devices.—*Perkin-Elmer Corp., Norwalk, Conn.*

CIRCLE 230 ON READER-SERVICE CARD



DON'T JUST BURN about poor temperature control

Do something!

Good way to cool down this hot problem: Standardize on *reliable* Bristol pyrometer supplies and accessories. You'll have taken a *big* step toward elimination of costly temperature control down-time. Remember, even the best pyrometer system depends on its accessories.

Bristol thermocouples, protection tubes, radiation-unit accessories, refractory insulators, mounting fixtures, thermocouple extension wire, switches, and ink are *field-proven for reliability.* They are the product of 70 years of instrument-building experience and 55 years in industrial pyrometry.

Write for complete data on Bristol pyrometer accessories today. Sizes and types to fit all standard installations. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. 0.13

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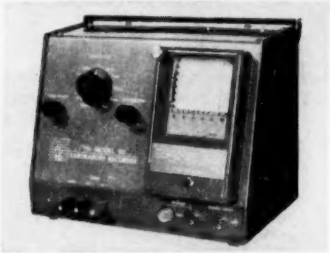
CIRCLE 99 ON READER-SERVICE CARD

LAB RECORDER

New Laboratory Recorder, Model 80, consists of a high-gain feedback-stabilized amplifier coupled to a milliammeter that can serve as either an indicator or recorder. The milliammeter is the chopper-bar type of record-

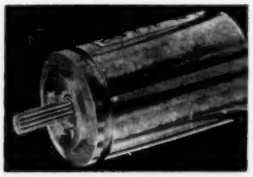


ing D'Arsonval movement manufactured by Rust Instrument Co. (called Rustrack recorder). The amplifier is based upon conversion of the d-c input into a-c by a vibrating-reed chopper and has a power gain of 10,000. Bulletin contains details.—*Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio.*

CIRCLE 231 ON READER-SERVICE CARD

PRECISION SERVO MOTOR

New size-8 hi-temp Precision Servo Motor, Type 5009-09, measures only 0.863" long, weighs 1.2 oz and has



−55°C to +125°C ambient temperature range. Stall torque is 0.2 in oz, no-load speed is 6200 rpm at rated voltages of 26-v fixed phase and 40-v control phase, rotor inertia is 0.47 gm cm^2 and T/1 ratio is 30,000 rad/sec^2.—*John Oster Mfg. Co., Avionic Div., 1 Main St., Racine, Wis.*

CIRCLE 232 ON READER-SERVICE CARD

STANDARD VU METERS

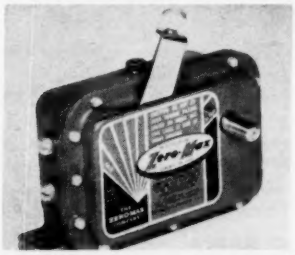
New line of Standard VU Meters is available in 2½", 3½", and 4½" sizes, round or rectangular, and in

either acrylic or phenolic cases. Features include double-bridge d'Arsonval movement with wide band, and full bridge rectifiers.—*Pace Electrical Instruments Co., Inc., 70-31 84th St., Glendale, L. I., N. Y.*

CIRCLE 233 ON READER-SERVICE CARD

VARIABLE SPEED DRIVES

New 400-Series stepless Variable Speed Drives have built-in safety disconnect and a new control for fast and precise speed setting. Other features include a larger input shaft on



the smaller models; wider mounting pads; double slotted holes for greater stability and easier alignment; up to 40% decrease in heat rise over ambient; improved gasketing and oil seals and non-heat-conducting control knobs. Lubricant is shipped with each unit. Stable drive with constant torques from 3 to 450 in-lb is provided.—*Zero-Max Co.*, 1904 *Lyndale Ave., South, Minneapolis* 5, *Minn.*

CIRCLE 234 ON READER-SERVICE CARD

ACCELEROMETER

New self-calibrating Accelerometer, Model AS 1025, permitting calibration before and during the actual flight of missiles or aircraft, utilizes a dual seismic system, with one element as the driver and the other sensor, to obtain the novel self-calibrating technique. An airborne oscillator assists in pre-flight and in-flight checkouts after installation of the accelerometer. Model AS 1025 has side mounted connectors; Model AS has top mounted connectors.—*Gulton Industries, Inc.*, 212 *Durham Ave., Metuchen, N. J.*

CIRCLE 235 ON READER-SERVICE CARD

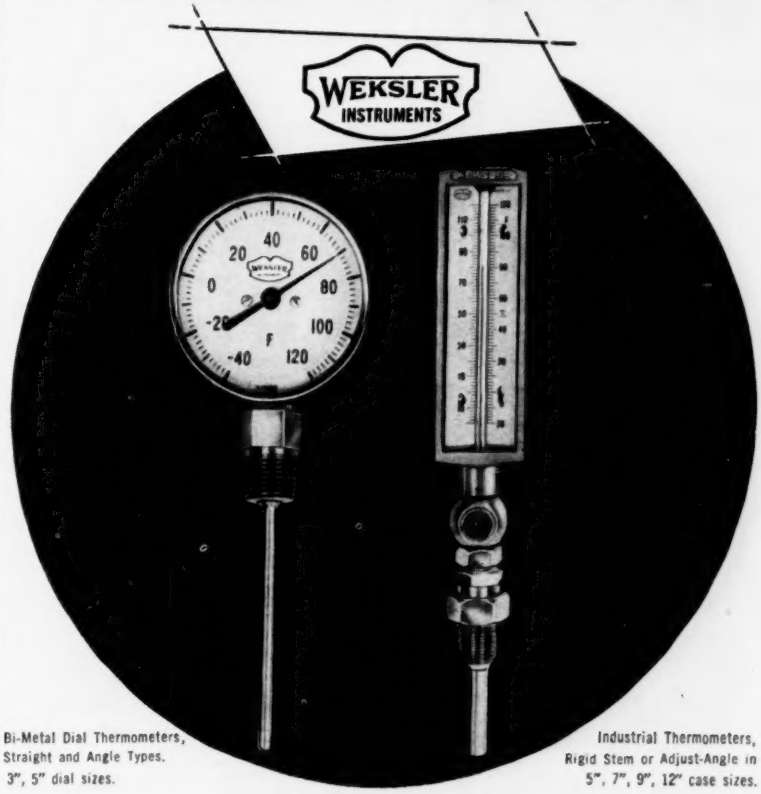
TIME INDICATORS

New, compact electromechanical Sodeco hours, minutes, and seconds indicators available in 4- or 5-digit models, designated Types HTCeZ4E and HTCeZ5E, respectively, indicate time

when pulsed each minute, second, 1/5 or 1/10 sec by a suitable impulse transmitter. Models have instantaneous mechanical toggle-type zero reset; are also available (Type HTCeF) with remote reset. Power requirements are 1.6 w at 24 vdc.—*Landis & Gyr, Inc.*, 45 *West* 45*th St., New York* 36, *N. Y.*

CIRCLE 236 ON READER-SERVICE CARD

SYMBOL OF QUALITY



Bi-Metal Dial Thermometers, Straight and Angle Types. 3", 5" dial sizes.

Industrial Thermometers, Rigid Stem or Adjust-Angle in 5", 7", 9", 12" case sizes.

in Liquid-In-Glass Industrial and Bi-Metal Thermometers

Indicating and recording instruments for temperature, pressure and humidity. *This is our one and only business.*

Our modern suburban plant, precision equipment and skilled people are here for one purpose:

To design, engineer, produce and deliver the most complete and finest line of instruments in our field of specialization that you'll find . . . *anywhere!*

The Weksler Specification Bulletin covers indicating and recording pressure gauges, industrial thermometers, dial thermometers, recording thermometers, recording hygrometers, bi-metal thermometers, laboratory thermometers and hydrometers. *Write for your copy.*

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Indicating and Recording Instruments for Temperature, Pressure and Humidity

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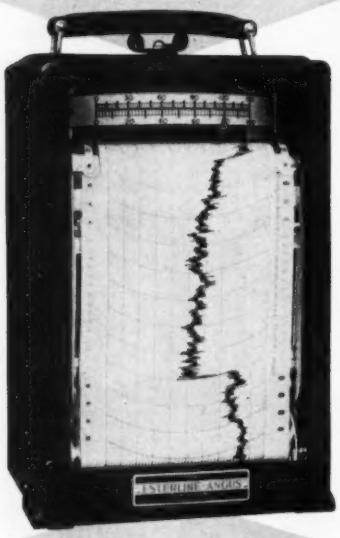
IZZITA
-AC Voltmeter? Yes
-AC Ammeter ? Yes
-DC Voltmeter? Yes
-DC Ammeter ? Yes



Yes, the handy
Esterline-Angus
Multi-Purpose
Recorder is all 4

Here are some of the more popular combinations in which this Recorder is available.

AC-DC Ammeter-Voltmeter
0-50 MA*, 0-5 A AC; 0-100 MV DC†; 0-150/300/600 V AC & DC.

AC Ammeter-Voltmeter
0-50 MA*, 0-5.0/10 A, 0-150/300/600 V.

AC-DC Ammeter
0-50 MA*, 0-2.5/5.0 A AC; 0-100 MV DC†.

AC-DC Voltmeter
0-150/300/600 V AC and DC.

*0-50 MA range for use with split-core current transformer having 50 MA secondary.

†0-100 MV range for use with 100 MV shunts.

Write us your requirements or send for Catalog Section 48.

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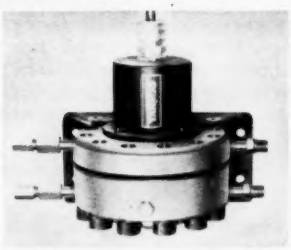
CIRCLE 101 ON READER-SERVICE CARD

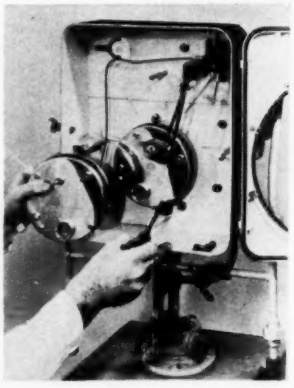
DIFF PRESSURE TRANSMITTER

New Differential Pressure Transmitter consists of a diaphragm mechanism in a pressure housing and a sensing coil which operates the remote receiver over cable connections. It is connected to the liquid vessel, fluid line, or other container by two tubes.—*Yarnall-Waring Co., Chestnut Hill, Phila.* 18, *Pa.*



CIRCLE 237 ON READER-SERVICE CARD

GAS-DRIVEN CHART DRIVE

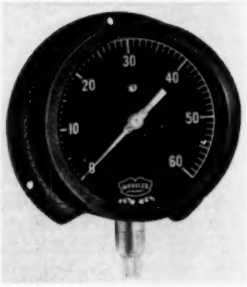


New Gas-Drive, a completely self-contained air- or gas-powered instrument-drive and timing unit, is particularly applicable for remote location installations. Features include a self-starting mechanism which is in-tion, installation in any position, and accuracy uneffected by supply pressure fluctuations.—*Rockwell Mfg. Co., Meter and Valve Div.,* 400 *Lexington Ave., Pittsburgh* 8, *Pa.*

CIRCLE 238 ON READER-SERVICE CARD

PRESSURE & VACUUM GAGES

New Royal line of custom-made Gages features accuracy of ½ of 1%, heavy-duty monel and inconel bushed rotary movement, and a micrometer 3½", 4½", 6" and 8½". Bourdon elements are made from phosphor bronze, silver brazed to forged brass socket; alloy steel, welded to forged alloy steel socket; stainless steel, silver-welded to stainless steel socket; beryllium copper, silver-brazed to forged brass socket. Chemical diaphragm attachments are available.—*Weksler Instruments Corp.,* 195 *East Merrick Rd., Freeport, N. Y.*



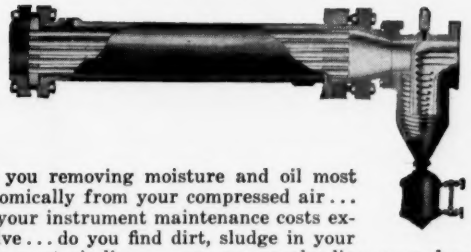
CIRCLE 239 ON READER-SERVICE CARD

LOADING REACTOR

New Exel, self-contained Loading Reactor, provides a convenient inductive load which can be made adjustable by using in conjunction with a Powerstat variable transformer. Essentially it consists of a gapped, strip-wound silicon steel toroid core, wire-wound and imbedded in epoxy compound. Data sheet SE-L2606 gives details.—*Superior Electric Co., Dept. LR2, Bristol, Conn.*

CIRCLE 240 ON READER-SERVICE CARD

What are *your* Instrument Air Costs?



Are you removing moisture and oil most economically from your compressed air . . . are your instrument maintenance costs excessive . . . do you find dirt, sludge in your instrument air lines . . . are you overloading your chemical air drier?

Clean, dry air will eliminate instrument difficulties and production down time. Over 90% of the moisture contained in the average compressor discharge can be eliminated with the use of an Adams Aftercooler and Cyclone Separator providing 2° F. cooling — that is cooling the compressed air discharge to within 2° of the cooling water temperature. The moisture and oil vapors thus condensed are efficiently removed by the Cyclone Separator over the entire operating range. In many cases this air is entirely satisfactory for motor-air or other control applications. Where bone dry air is indicated requiring further chemical drier treatment, its load can be minimized to a polishing action. Thus, the bulk of the water is removed by lower cost condensation.

Why not investigate the many advantages of the Adams Aftercooler - Separator combination. Write today for Bulletin 714.

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For all loads up to 60 Amps or 5 H.P.

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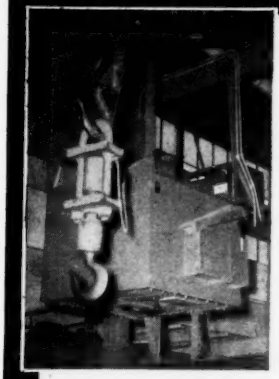
Ametron® ELECTRONIC CRANE SCALES



Weighs heavy loads suspended from crane hook. Printer, located in crane cab or other convenient location, records weight on tape or cards. New compact printer only 22″ x 18″ x 10½″.

Entire assembly designed for prompt and easy installation. Now available at new low cost. Capacities 5, 10, 15 tons.

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THE STANDARD OF ACCURACY SINCE 1888

STREETER-AMET COMPANY
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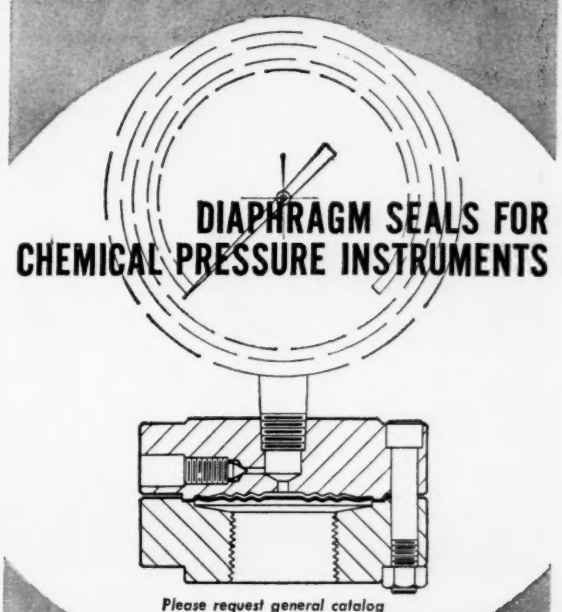
THE MOST COMPLETE LINE



DIAPHRAGM SEALS FOR CHEMICAL PRESSURE INSTRUMENTS

Please request general catalog

MANSFIELD & GREEN INC.
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MEASURE ABSOLUTE PRESSURES

with SPEED and PRECISION

With Wallace & Tiernan Aneroid Dial Indicators you get precision and fast response in all types of absolute pressure work.

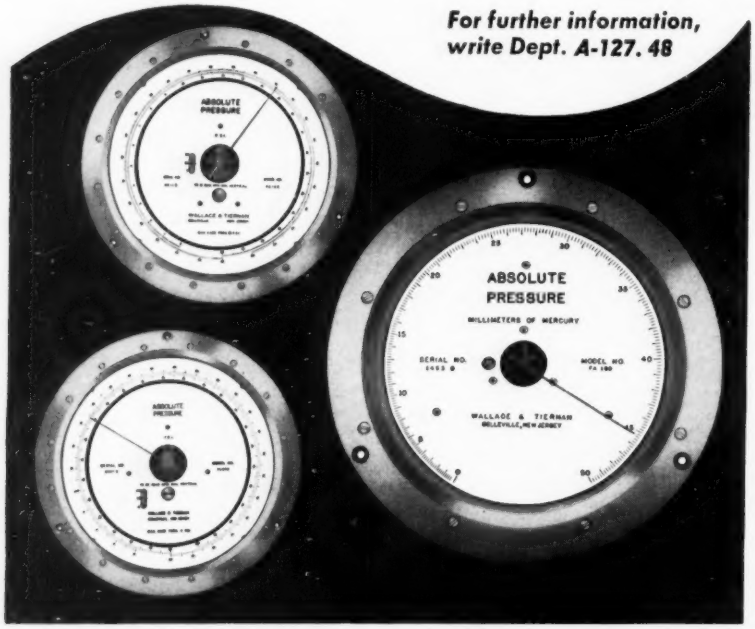
W&T Precision Indicators have many uses in research and development engineering. One is ideal for calibrating pressure transducers; another, for checking the calibration of flight instruments and ground support equipment. These instruments also keep constant check on continuous production-line work.

A W&T Absolute Pressure Gauge on the job means:

- ★ Accuracy 0.1% to 0.33%
- ★ Sensitivity 0.01% to 0.2%
- ★ Range 0.1-20 mm Hg to 0-500 p.s.i.a
- ★ No corrections
- ★ Light weight, small size

The accuracy of W&T Absolute Pressure Indicators approaches that of liquid columns... higher sensitivity assures faster response... large dial gives quick reading.

For further information, write Dept. A-127. 48



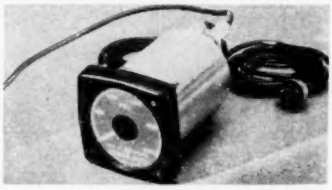
WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 106 ON READER-SERVICE CARD

PRESSURE INDICATOR

New Teledyne Model 236 Pressure Indicator consists (1) of a voltage-regulated power supply for furnishing 60-cps excitation to a strain gage bridge, (2) a transistor amplifier to



increase the voltage level of the bridge output to the d-c meter movement, and (3) a self-contained power supply for the transistor amplifier. Applications are in the measurement of fluid and gaseous pressures, thrust, torque, and similar phenomena. Price List P-59236 gives details.—*Taber Instrument Corp., North Tonawanda, N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

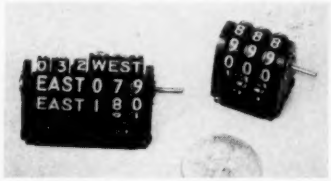
HOT PLATE

New, round Hot Plate Type 2300 Thermolyne for lab and shop applications incorporates a thermostatic control unit for precision control from 6 to 370°C (700°F). A built-in anticipatory sensing device results in negligible overshoot in initial heat-up, and temperature variation thereafter falls within ±3°C. Bulletin HP-231 gives details.—*Thermo Electric Mfg. Co., 536 Huff St., Dubuque, Iowa.*

CIRCLE 242 ON READER-SERVICE CARD

MINI INSTRUMENT COUNTERS

New Miniature Precision Instrument Counters, developed for use in military inertial guidance navigation systems, are also suitable for other applications. The 3-figure counter

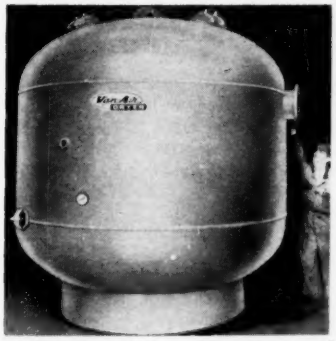


(right) registering up to 999 and repeat, non-reset, has a ball-bearing mounted shaft and can be operated at 1500 rpm. The Tandem Counter (left) is equipped with a shutter which is actuated in either direction whenever a transfer point is reached. It reads in east or west longitude, or in another application, in degrees of heading.—*Veeder-Root, Inc., Hartford 2, Conn.*

CIRCLE 243 ON READER-SERVICE CARD

COMPRESSED AIR DRYERS

New automatic Air Dryers with capacities of 10,000, 11,000 and 11,500 cfm at 100 psig intercept residual

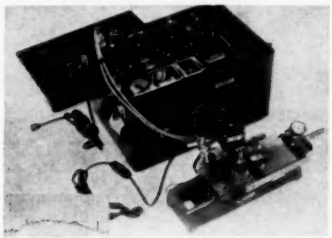


water-vapor along with microscopic abrasives and potent acid fumes which elude aftercooler, receiver and filters; and require no regeneration, heat or power.—*Van Products Co., 5842 Swanville Rd., Erie, Pa.*

CIRCLE 244 ON READER-SERVICE CARD

ELECTRONIC GEAR TESTER

New Electronic Gear Tester uses the Sanborn Electronic Recorder coupled with either the Scherr 2″ Gear Tester, the Scherr 5″ Gear Tester, or



the Parkson 9″ & 15″ Gear Testers. The recorder can be calibrated to any ratio within the limit of the recording tape. One line on the paper can be made to equal from 0.00005″ to 0.001″. Operates with an electrically-heated stylus. By the simple adjustment of a knob the stylus temperature can be adjusted to give a fine or a heavy line.—*Scherr-Tumico Co., 200 Lafayette St., New York 12, N. Y.*

CIRCLE 245 ON READER-SERVICE CARD

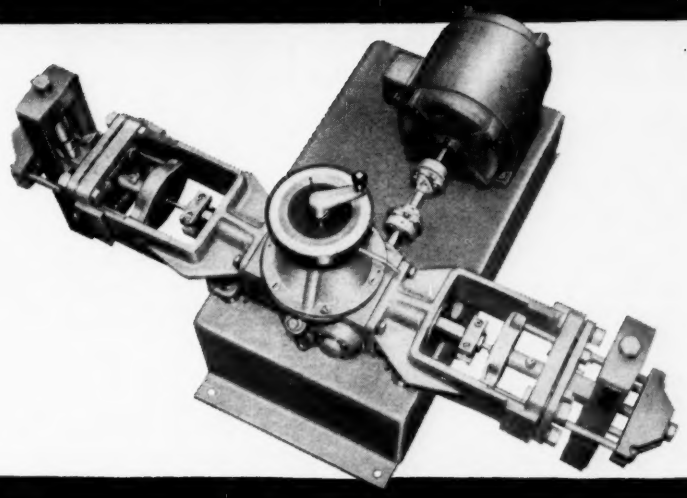
MAGNETIC STORAGE DRUM

New Magnetic Storage Drum, Model 7508, has 250-tracts, 460, 800-bit capacity, and 3072 bits per track.

Guaranteed runout is less than 0.0001″ TIR. Speed range is 900 to 6,000 rpm. Compatible with MIL-E-4158A and MIL-E-16400B specs.—*Bryant Computer Products Div., Box 620, Springfield, Vt.*

CIRCLE 246 ON READER-SERVICE CARD

We Researched Over 15 Industries



Before We Designed This New Pump

From Maine to Texas we explored refineries, paper mills, pharmaceutical and chemical plants. Everywhere we found that metering operations—from pilot plants to proportional blending—were automated, efficient, ingenious. But there was room for an improved plunger pump. A pump that would give more flexibility and convenience in modern metering operations . . . positive accuracy and dependability in metering bland or harshly corrosive liquids against pressure.

Because it's designed around these critical needs, the new Wallace & Tiernan Series 200 Metering Pump fills the bill. Here's how:

Flexibility Drive units may be ganged to meter several liquids. One, two, or three liquid ends on one drive increase capacity and smooth out pumping pulsations. Six stroking speeds, several plunger diameters, and many liquid-end materials add further flexibility. "Stop-Adjust" and "Run-Adjust" models are available. On the latter, automatic stroke-length control, including ratio control, is easily achieved.

Convenience For different capacities or liquids, self-aligning liquid ends are quickly changed as complete units—a real convenience in pilot plant study. Bases for the Series 200 Pump may be steel plate, pipe, or structural shapes. A unique arrangement of eccentrics drives the plunger. This eliminates rocker arms and makes for the responsive, convenient stroke-length control industry needs.

Dependability The Series 200 Pump's design and materials mean resistance to wear and corrosion, less maintenance, and dependable operation. The drive is powered by a standard electric motor. Heavy ball bearings, forced-feed lubrication, and no cantilever bearing loads also assure long-lasting dependability.

Accuracy The Series 200 Pump meters accurately against up to 4,000 psi in the lower ranges (minimum 0.65 gph). And it meters any set amount, time after time, within ±1%—the kind of accuracy modern quality-controlled blending must have.

In every feature, the new Series 200 Pump is designed with modern industrial processing in mind. Component by component and feature by feature, you, the industrial user, called the shots. You specified the new W&T Series 200 Metering Pump.

For more on this user-inspired pump, write today to Dept. L-5.48.

WALLACE & TIERNAN INCORPORATED

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CIRCLE 107 ON READER-SERVICE CARD

Lepel

HIGH FREQUENCY INDUCTION HEATING UNITS

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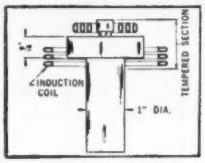
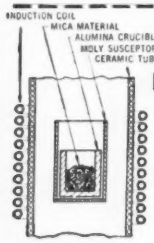
Lepel induction heating equipment represents the most advanced thought in the field of electronics... the most practical and efficient source of heat developed for numerous industrial applications. You are invited to send samples of work with specifications. Our engineers will process and return the completed job with full data and recommendations without cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS



Punch Heads Selectively Tempered

Diagram shows arrangement for selectively tempering heads of alloy steel punches. The use of a combination type solenoid and pancake induction coil reduces hardness from Rc 55/56 to Rc 41/44, improving resistance to brittle fracture at the head of the punch. In this case a heating cycle of 55 seconds provides uniform tempering. A multiple position fixture, processing 4 pieces at one time, speeds up production.



Heating Non-Conducting Materials To High Temperatures

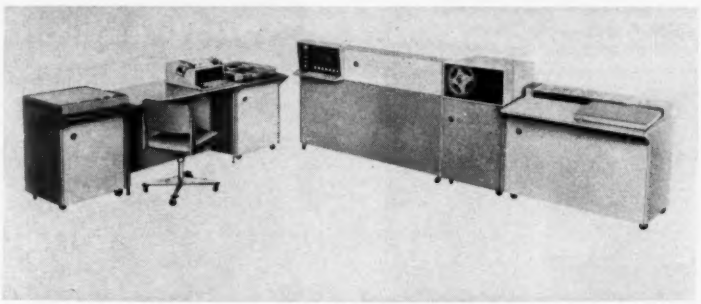
Laboratory analyses frequently require heating of non-conducting materials to temperatures of 3,000 to 3,500° F. in vacuum or special atmosphere. This can be accomplished by induction heating with the aid of a metal susceptor. Diagram shows the fusion of mica samples in an alumina crucible, using molybdenum susceptor. A ceramic tube surrounding the susceptor isolates the work for fusion in a vacuum. The molybdenum susceptor is heated by induction, which in turn, heats the crucible by radiation.

WRITE FOR NEW LEPEL CATALOG
Electronic Tube Generators from 1 Kw to 100 Kw.
Spark Gap Converters from 2 Kw to 30 Kw.

Lepel HIGH FREQUENCY LABORATORIES, INC.
55th ST. & 37th AVE., WOODSIDE 77, N. Y.

CIRCLE 108 ON READER-SERVICE CARD

MODULAR ELECTRONIC DATA PROCESSING SYSTEM

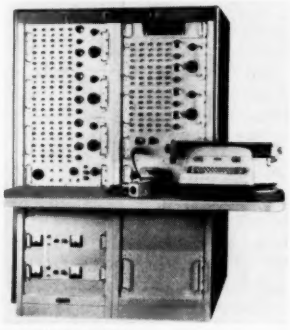


New fully-transistorized modular electronic Data Processing System RPC-9000 for automatic "in line" records-processing, accepts data in random order. The basic system includes: (1) a central processing and control unit which operates in microsec, performs the calculations, controls the program, and searches the external memory tape; (2) a continuous magnetic tape file for data storage; an input-output tape typewriter system that reads paper tape at 60 characters/sec, and punches tape at 30 characters/sec. Optional high-speed input-output units include: a 400 cards/min photoelectric reader for rapid input of data contained in 80-column punched cards; a 500-characters/sec bi-directional photoelectric paper tape reader; a 300-characters/sec tape perforating unit; a 150-lines/min printer (of 120 alpha-numeric characters each); a high-speed 666 or 1,000-lines/min printer (of 120 alpha-numeric characters each); additional tape typewriter systems for on-line or off-line use and additional paper tape punch/read on-line units. Information can be entered into the computer from punched paper tape, punched cards, or through the typewriter keyboard. No binary conversion is necessary for machine computation. Internal operating memory consists of nine blocks of magneto-strictive delay lines capable of storing 432 instructions or seventy-two 12-character words of data. The external data memory is contained on endless loops of magnetic tape. Each tape loop will store up to 1,000,000 alpha-numerical characters.—*Royal McBee Corp., Port Chester, N. Y.*

CIRCLE 247 ON READER-SERVICE CARD

STRAIN GAGE RECORDER

New wide-range Digital Recording System, Model ASB-100VS, for all combinations of strain gages and strain gage transducers, scans automatically 100 channels of information and is easily expanded to 200 channels by adding scanning units. Strain is read directly in μin/in over the range of +10,000 to −10,000 by a direct voltage-ratio-to-digital converter at the rate of approximately 1 channel/sec. Bulletin 109 gives details.—*Bytrex Corp., 50 Hunt St., Newton 58, Mass.*



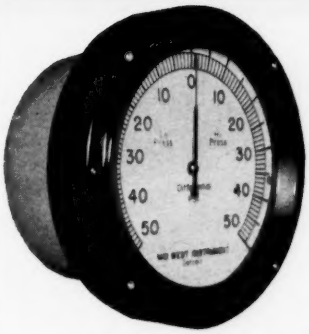
CIRCLE 248 ON READER-SERVICE CARD

INDICATING BELLOWS METER

New bellows-type 6" Indicator for flow and liquid level is made in differential ranges from 0-20" to 0-400", which can be changed in the field. A micrometer zero adjustment is located on the pointer. Calibration and span adjustment can be made without removing the dial. Calibrated accuracy is ±1% full scale for ranges of 0-50" WC or above, and ±1¼% full scale for range below 0-50"WC. Standard scale calibrations are 0-100 linear or 0-10 and 0-100 square root.—*Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne & Windrim Aves., Phila. 44, Pa.*

CIRCLE 249 ON READER-SERVICE CARD

New—EASY PANEL MOUNTING



MID-WEST DIFFERENTIAL GAUGES

Offer These Plus Features

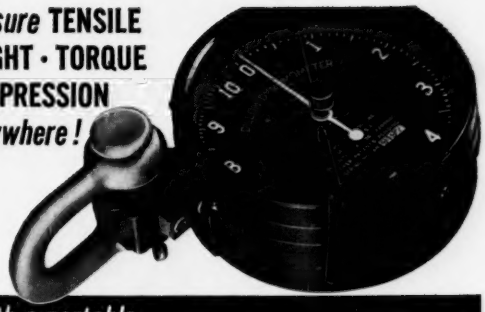
- 4,000 psi Working Pressure
- Encapsuled Bourdon Tube Element
- Easy Panel Mounting
- Light Weight Aluminum Case
- Standard and Precision Types

Mid-West's Encapsuled Bourdon Tube Element introduces a new concept in differential pressure gauges. New jewelled bearing movement assures magnetic transmission of Bourdon Tube motion—with extremely low hysteresis and tracking error. Dial ranges from 100 in. H_2O to 400 PSI differential.

MID-WEST INSTRUMENT DIV., ASTRA ASSOCIATES, INC.
1021 E. State Fair, Detroit 3, Michigan
Tel: TWinbrook 3-8250

CIRCLE 109 ON READER-SERVICE CARD

Measure TENSILE WEIGHT · TORQUE COMPRESSION —anywhere!



with a portable

Dillon Dynamometer

- 13 CAPACITIES: 0-500, 0-1000, 0-2500, 0-3500, 0-5000, 0-10M, 0-15M, 0-20M, 0-30M, 0-40M, 0-50M and 0-100M pounds.
- Choice of dial sizes: 5" or 10" diameter.
- Equipped with attachment shackles and pins.
- Dial protected by shatter-proof crystal.
- Will withstand accidental overloads.
- Has max. pointer to register peak loads.
- Extremely compact. Requires little headroom.
- Lightweight yet rugged. Easy to handle.

YOURS FREE! Profusely illustrated catalog showing applications and prices. Write **today!**

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W. C. Dillon & COMPANY, INC.
14584 Keswick St.
Van Nuys 13, Calif.

CIRCLE 111 ON READER-SERVICE CARD

Gage Block Precision means GRADE "A" ACCURACY*

with **ULTRA-CHEX GAGE BLOCKS**

82 PIECE SET...

NOW ONLY $249.50

*Grade "A" Accuracy: −.000002" and +.000006"

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PRECISION MEASURING TOOLS AND INSTRUMENTS

WAREHOUSE STOCK, SHOWROOMS & SALES OFFICES AT
NEW YORK: 200 Lafayette Street, New York 12, N. Y.
ST. JAMES: St. James, Minnesota
LOS ANGELES: 3337 West Olympic Blvd., Los Angeles 19, Cal.
CHICAGO: 5045 W. Harrison, Chicago 44, Ill.
When writing to any of the above locations, refer to Dept. U-5

CIRCLE 110 ON READER-SERVICE CARD

SOMETHING REALLY NEW IN PANEL METERS!

THIS SLIM-LINE, TRIM-LINE STYLIST

Have a look at the most distinctively different meter design in years. Start with styling (as your customers do): note the thoroughbred leanness, the crisply drawn detail, the overall look of precision. Consider function: see how the picture-window dial is recessed and angled back for easier reading. Ponder practicality: observe that the self-trimming case is installed with just a single panel cutout. Sample the specifications: choose from two sizes—Model 561, 5" x 2⅞", and Model 361, 3½" x 2"; both in satin-finish Bakelite; both available in standard microampere, ampere, millivolt and volt ranges, AC or DC. Prices and other data? Ask for Bulletin 107.

api **ASSEMBLY PRODUCTS, INC.**
Chesterland 10, Ohio S.A. 2142

CIRCLE 112 ON READER-SERVICE CARD

Stearns electro-magnetic

miniature CLUTCHES

STYLE "SM"*

Now Available in **6 Standard Sizes**

* Stationary Magnet

Installation-Proved Reliability . . .

Users' expressed satisfaction on the long life and maintenance-free operation of the thousands of SM's in use on their applications confirms the advantages of the heavy-duty design and construction features of these units.

Wide Range of Size and Torque . . .

Six Sizes (shown above) — 7/8, 1 1/8, 1 13/16, 2 1/8, 2 5/8, 4 1/4 in. square. Max. Torques Range from 25 oz in. to 240 lb in.

✓ Check—Compare these $aving Advantages:

1. Heavy-Duty Construction for long, trouble-free life. Heavy-gauge frame resists distortion. Solid-type, low-carbon "Armco" steel armature for greater strength and longer wear. Solid, molded, fully finished metallic and asbestos friction element for longer, efficient life than a thin cemented facing. All wear elements can be quickly, easily replaced, if required, at low cost.
2. Fast, Easy Installation . . . stationary field with flange-type mounting. Most sizes available with option of extended, ball-bearing-mounted driven hubs for integral sheave or pulley mounting.
3. Self-Adjusting.
4. No slip-rings or brushes to install or maintain. Furnished standard with 12-in. to 14-in. wire leads. Terminal block or plug-in connections are optional.
5. Moisture-, Corrosion-Resistant . . . coil is embedded in an epoxy resin compound—not merely coated. All metal parts finished with a chromate-converted zinc plating.
6. Fast, Positive Actuation.
7. Assures accurate, dependable, power or motion control energized by any adequate switching device.

For Superior Performance—Reliability . . . Specify Stearns!

Contact your local Stearns Representative for complete data and information on how to obtain prototype units for your specific installation. Or write direct, stating specific application information. Request Bulletin No. 504-BV.

BRAKES · STEARNS ELECTRIC · CLUTCHES · MILWAUKEE

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120 North Broadway, Milwaukee 2, Wis.
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THE COMPLETE LINE OF CLUTCHES . . . BRAKES . . . CLUTCH-BRAKES

CIRCLE 113 ON READER-SERVICE CARD

CR-TUBE MAGNETIC SHIELD

New sectional design for Netic Co-Netic cathode-ray-tube Magnetic Shields gives effective shielding yet provides easy access to tube where space is limited. Simple tooling allows

production at lower cost than conformal shields. Made in multi-lamina construction or single-layer shields. Can be supplied in many configurations: Round, rectangular, square, etc. with or without integral mounting brackets. The Netic Co-Netic alloys are non-shock sensitive, non-retentive and do not require periodic annealing to maintain shielding effectiveness.—*Magnetic Shield Div., Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.*

CIRCLE 250 ON READER-SERVICE CARD

CARTESIAN MANOMETER

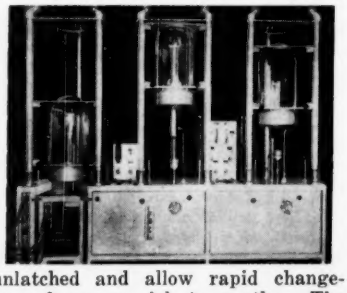
New Cartesian Manometer simplifies measurement in the difficult 0-10-mm region of absolute pressure meas-

urement. It magnifies the pressure readings by a factor of 10, making 0-10 mm Hg appear on an easily-readable scale of 100-mm length. A stopcock adapts it to differential or absolute readings.—*Manostat Corp., 26 North Moore St., New York 13, N. Y.*

CIRCLE 251 ON READER-SERVICE CARD

INDUCTION BRAZING

New line of production fixtures to braze metal assemblies under a controlled atmosphere by induction heating, includes fixed and caster-mounted heating stations which can be quickly



unlatched and allow rapid changeover from one job to another. The work stations are operated from a single induction heating generator. The heating cycle is automatically controlled at each station by a preset timer.—*Lepel High Frequency Labs., Inc., 55th St. and 37th Ave., Woodside, N. Y.*

CIRCLE 252 ON READER-SERVICE CARD

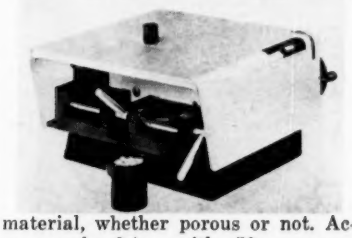
COMPUTER TYPEWRITER

New automatic-sequence controlled Computer Typewriter computes figures properly, regardless of their position on the form. The 910 Computer Typewriter automatically types all extensions, sub-totals, and totals. Consisting of a standard Royal electric typewriter, linked to a computing unit through an encoding/decoding component, it is housed in a console that stands adjacent to the typewriter desk. Machine features include the ability to make logical decision, automatic round-off to full cents, automatic leading symbol printing and others.—*Royal McBee Corp., Port Chester, N. Y.*

CIRCLE 253 ON READER-SERVICE CARD

TRUE VOLUME OF GRANULAR MATERIAL

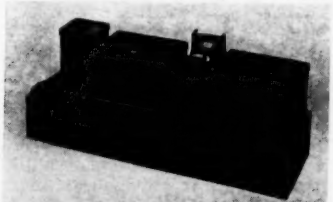
New Model 200 Pycnometer uses no liquids, only air, to determine true volume of granular, powdery or flaky material, whether porous or not. Accuracy is 0.1cc with 50-cc cup.—*Houston Instrument Corp., Box 22234, Houston 27, Tex.*



CIRCLE 254 ON READER-SERVICE CARD

TUBELESS POWER SUPPLY

New regulated supply contains a reactor and a hermetically-sealed constant-voltage transformer. Featured is a time delay relay adjustable from 30 sec to 3 min to allow for warm-up. Input of the unit is 95 to 130 vac at 60 cps, output is 115 vdc at 150 milliamp, regulated to ±1%. Ripple is less than 10 mv.—*Freed Transformer Co., Inc., 1718 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.*



CIRCLE 255 ON READER-SERVICE CARD

Resistance Measuring BRIDGES

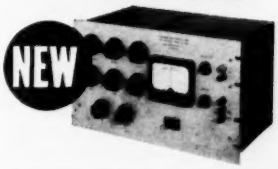
Laboratory Accuracy . . . Production Line Efficiency

There is a Shallcross Bridge for measuring resistance to almost any desired precision . . . and with the ease of operation and speed required for production and inspection work as well. Each instrument uses Shallcross precision wirewound resistors and Shallcross instrument-type switches for maximum stability and long, maintenance-free accuracy.

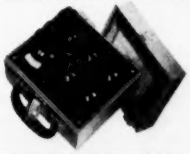
Beyond the most popular bridges illustrated here, Shallcross regularly supplies many other standard models as well as special purpose bridges for unusual applications. For information about any type, address: SHALLCROSS MANUFACTURING CO., 12 Preston St., Selma, North Carolina.

PERCENT LIMIT BRIDGES

10 standard models for production testing of resistors up to 11,111,100 ohms on a "GO-NO GO" basis. Separate + and — percentage selectors adjust from ±0.1% to ±20%. Also usable for direct resistance measurements down to 0.00001 ohm on some models.



RACK-MOUNTED MODEL 617-07 has built-in electronic galvanometer for far greater sensitivity, accuracy, and speed than models with moving coil null indicators.

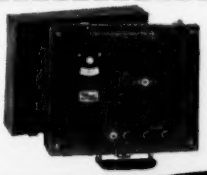


WHEATSTONE-FAULT LOCATION BRIDGE

A 5-dial Wheatstone Bridge for lab or field work. Also locates grounds, opens, & shorts by Murray, Varley, Hilborn or Fisher Loop tests.

MEGOHM-WHEATSTONE BRIDGE

A three unit assembly consisting of a dual range power supply, 4-dial Wheatstone Bridge and a combination dc amplifier and null detector. Accurately measures resistances up to 1,000,000 megohms to four significant figures.

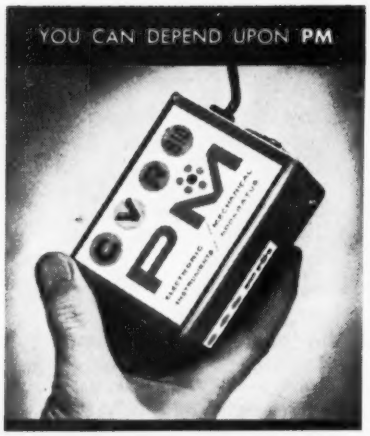


KELVIN-WHEATSTONE BRIDGE

This Shallcross-pioneered combination instrument has overlapping Kelvin & Wheatstone ranges selected by a single ratio dial. Range: 0.000001 ohm to 11.11 megohms.

Shallcross

CIRCLE 114 ON READER-SERVICE CARD



CVR-610

CONSTANT VOLTAGE REFERENCE INSTRUMENT POWER SUPPLY

for those difficult environmental applications in which loss of control or shut down due to battery failure cannot be tolerated

Install the CVR-610 without tools or instrument modification. A direct replacement for #6 or 4FH battery, it can be installed with very little more time and effort than is required to change a dry cell. Use with Leeds & Northrup, Brown, Minneapolis Honeywell and others.

$62.50

SPECIFICATIONS

OUTPUT
1.5 Volts DC nominal will supply either 6 or 10 MA circuits.

STABILITY
Within 0.1% with line variations from 105 to 125 volts, 50 to 60 cycles.

NOISE
Injects less than 10 microvolts into standard measuring circuits.

TEMPERATURE
Minus 20 to + 140 F.

***PM** instruments can measure:*
LOAD • THRUST • TORQUE • FLOW
WEIGHT • TEMPERATURE • DISPLACEMENT
VOLTAGE • PRESSURE with the highest accuracy attainable in industrial and laboratory applications.

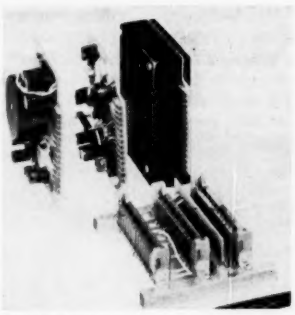
PM

PERFORMANCE MEASUREMENTS COMPANY
15120 Third Avenue, Detroit 3, Michigan

CIRCLE 115 ON READER-SERVICE CARD

SOLID-STATE D-C AMPLIFIER

New completely solid-state D-C Amplifier, Model DCA-1-B, features plug-in modules and extremely small size (4¾" x 3½" x 4¼"). It is an operational, wide-band, high-accuracy amplifier with a solid-state chopper. Specifications include frequency response exceeding —3db at 200 kc; gain accuracy of ±0.03%; linearity and stability at ±0.02%; and drift of 500 μv referred to input.—*Packard Bell Computer Corp.*, 1905 *Armacost Ave., Los Angeles* 25, *Calif.*



CIRCLE 256 ON READER-SERVICE CARD

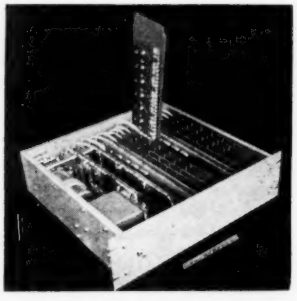
MAGNETIC AMPLIFIER

New Model 1201 low-level D-C Signal Amplifier incorporates an adjustable network to adapt it to a range of sensor voltages (from 0-1 mv to 0-500 mv) and impedances. For all sensors, the output of the amplifier is 0-5.0 vdc powered from 28 vdc ±5%. Characteristics of amplifier include—output signal: for all types of sensors indicated 0-5.0 v; output linearity: 1% of full scale (±50 mv); output ripple: 50 mv rms max; frequency response: approx. 2 cps.—*Lumen, Inc., Moen Ave., Box* 905, *Joliet, Ill.*

CIRCLE 257 ON READER-SERVICE CARD

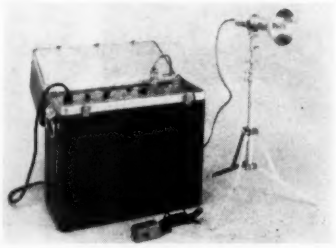
MIXTURE RATIO COMPUTER

New Mixture Ratio Computer uses digital and analog techniques to simplify flow rate control problems. Digital counters determine the periods of two input frequencies from flow meters. Digital-to-analog conversion provides two outputs: one voltage proportional to flow rate error and another proportional to mixture ratio error. References are selected by digital registers. Accuracy of both outputs at null is 0.1%. System utilizes solid-state components throughout.—*Redcor Development Corp.*, 14750 *Arminta St., Box* 309, *Van Nuys, Calif*



CIRCLE 258 ON READER-SERVICE CARD

ELECTRONIC FLASH UNIT



New portable Model 357 Electronic Flash Unit has a capacity of 1200 watt sec. It delivers a single flash of cold light whose duration is controllable to correspond with the writing rate of the camera. Waveform of the light pulse is square to provide even illumination on all frames. Duration settings are 8.70, 11.15, 14.75, and 22.25 msec. Rise and decay times of the pulse are in the order of 40μsec. Operation is from a 115-v/60-cps/5-amp integral power supply.—*Beckman & Whitley, San Carlos, Calif.*

CIRCLE 259 ON READER-SERVICE CARD

GREEN *Pantograph Engravers*

ELIMINATE DELAYS!

Keep the work in your own plant.

PORTABLE 40-POUND BENCH-MODEL 106

Famous 2 or 3-dimensional engraver, successfully used by thousands, features 5 positive, accurate pantograph ratios. Versatile ball bearing spindle has three speeds up to 14,000 rpm; height of pantograph and position of cutter are continuously adjustable; one copy carrier (supplied) accepts all standard master type sizes.

The Model 106 has proven incomparable for speed and accuracy . . . yet reasonably priced.

Cutter grinders, rotary tables, master letters, compound slides, name plates and all required accessories. For complete information, write to

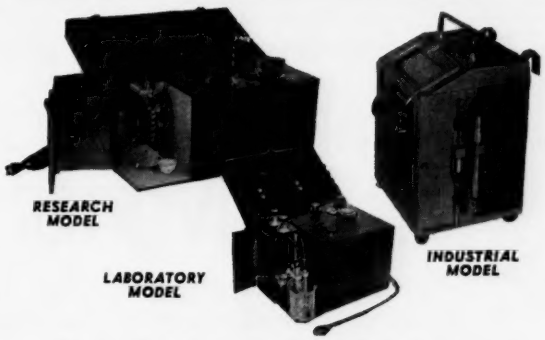
MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 375 pounds . . . rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Micrometer adjustment for depth of cut
- Ball-bearing construction throughout — super-precision ball bearing spindle
- Spindle speeds up to 26,000 rpm for engraving or machining modern materials
- Ratios 2 to 1 to infinity — master copy area 26" x 10"
- Vertical range over 10"

GREEN INSTRUMENT COMPANY, INC.

Dept. 86, 295 Vassar Street
Cambridge 39, Mass.

CIRCLE 116 ON READER-SERVICE CARD



Cambridge pH Meters

The three portable models illustrated above incorporate new and important advantages. A.C. line operation eliminates battery nuisance. Laboratory and Research models use electron-ray tube for precise null-point indication. Industrial model is direct-reading, continuous-indicating; ruggedly built for plant use.

Accuracy: Research .02 pH, Laboratory .05 pH, Industrial .10 pH. Cambridge pH equipment also includes single- and multi-point indicators and recorders. Send for Bulletin 910-M.

CAMBRIDGE INSTRUMENT COMPANY, INC.

1618 Graybar Bldg., 420 Lexington Ave., New York 17, N. Y.

Pioneer Manufacturers of

PRECISION INSTRUMENTS

CIRCLE 118 ON READER-SERVICE CARD

OPTICS

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS

TRowbridge 6-3368—3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBOLT FERRITE
COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

CIRCLE 117 ON READER-SERVICE CARD

PHILADELPHIA

THERMAL CONTROLS AND THERMOMETERS

Specify!
THE BEST!
A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.
SEND FOR CATALOG 110
Since 1905

PHILADELPHIA THERMOMETER CO.

4401 N. Sixth St. • Philadelphia 40, Pa.

CIRCLE 119 ON READER-SERVICE CARD

Hermes Solid State

BINARY TO DECIMAL CONVERTER

for converting any 4 bit code to decimal illuminated display

Performs better

...Costs less

Binary to Decimal Converter, Model 260, shown approx. ½ size

$95

(Nixie Bulb not included)

Discounts for quantity purchases

NO FALSE READOUTS
Relays and tubes eliminated

MAXIMUM RELIABILITY
100% solid state circuitry

LONG USEFUL LIFE
No preventive maintenance required

OPERATIONAL FLEXIBILITY
Variety of four bit codes can be converted

LATCHING CIRCUITS
Provide *memory* for binary information

Write for Technical Bulletin 260

Hermes

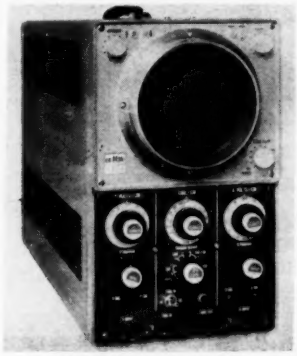
ELECTRONICS CO.

75 CAMBRIDGE PARKWAY, CAMBRIDGE 42, MASSACHUSETTS

CIRCLE 120 ON READER-SERVICE CARD

OSCILLOSCOPE

New Type 401-B low-frequency, general-purpose Oscilloscope features versatile synchronization perform-

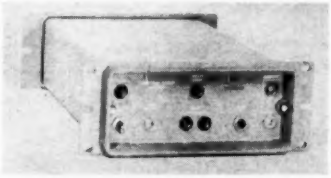


ance, bandwidth of 300 kc at 3 db down, and sensitivity of 10 mv/cm with identical X and Y amplifiers.—*Allen B. Du Mont Labs., Inc.*, 750 *Bloomfield Ave., Clifton, N. J.*

CIRCLE 260 ON READER-SERVICE CARD

BI-DIRECTIONAL COUNTER

New Model 500T Solid-State Add/Subtract Electronic Counter features anti-coincidence input circuits for Add/Subtract inputs, a digital-to-analog converter, and an excess error alarm. It is claimed that one of the



advantages of direct difference control is that an analog control signal can be obtained directly as the difference between two large numbers. The possible error in a digital-to-analog conversion of this type is significantly less than the difference of two analog quantities. Provides digital control of flow, rpm, positioning of parts, shearing, and many others.—*Erie Pacific*, 12932 *South Weber Way, Hawthorne, Calif.*

CIRCLE 261 ON READER-SERVICE CARD

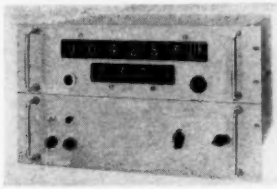
EXPENDABLE T/C

New expendable Immersion Thermocouple for measuring steel temperatures in open hearth and electric furnaces, or other molten metals, consists of a ceramic base which serves as a mounting for the noble-metal thermocouple wires (either Pt/Pt-10% Rh, or Pt/Pt-13%Rh). A firmly anchored transparent fused-silica tube protects the thermocouple wires and is, in turn, protected from slag and floating solids by a special metal cap. The cap absorbs the physical shock of immersion and melts away immediately after it has plunged beneath the slag.—*Engelhard Industries, Inc.*, 113 *Astor St., Newark, N. J.*

CIRCLE 262 ON READER-SERVICE CARD

DIGITAL CAPACITY METER

New transistorized Digital-capacity Meter automatically scans large numbers of capacitors measuring their ca-



pacitance and dissipation factors, converting them to their digital equivalents, and presenting the digital data in both visual and 10-line decimal-contact closure form. Features include: capacities from 10 mmfd to 999.9 mfd, dissipation factor from 0.001 to 0.999, accuracy from 1% and ±1 digit.—*Electro Instruments, Inc.*, 3540 *Aero Court, San Diego* 11, *Calif.*

CIRCLE 263 ON READER-SERVICE CARD

LUBRICATING COMPOUNDS

New Goop line of Anti-seize and Lubrication Compounds includes (1) Silver Goop to prevent seizing and galling regardless of applied load on threaded parts, at temperatures up to 2100°F, resisting water washout, (2) Blue Goop and (3) High Purity Goop, anti-seize and sealing compounds for titanium, s.s., aluminum and high-temperature alloys effective up to 400°F. Blue Goop is impervious to water washout, most acids and all petroleum solvents, High Purity Goop is impervious to moisture, high voltage and cyclic thermal stress.—*Crawford Fitting Co.*, 884 *East* 140*th St., Cleveland* 10, *Ohio.*

CIRCLE 264 ON READER-SERVICE CARD

MINI INFRARED SCANNER

New Farmer Type SA-IR Infrared Photoelectric Scanner, or Proximity Sensor, which combines a light-source and photocell in a single unit and

responds to metallic and non-metallic objects, senses objects or control-areas at distances up to 2". Unit measures 1⅛" dia x 2¼" lg.—*Farmer Electric Products Co., Inc.*, 2300 *Washington St., Newton Lower Falls, Mass.*

CIRCLE 265 ON READER-SERVICE CARD

HEISE GAUGES

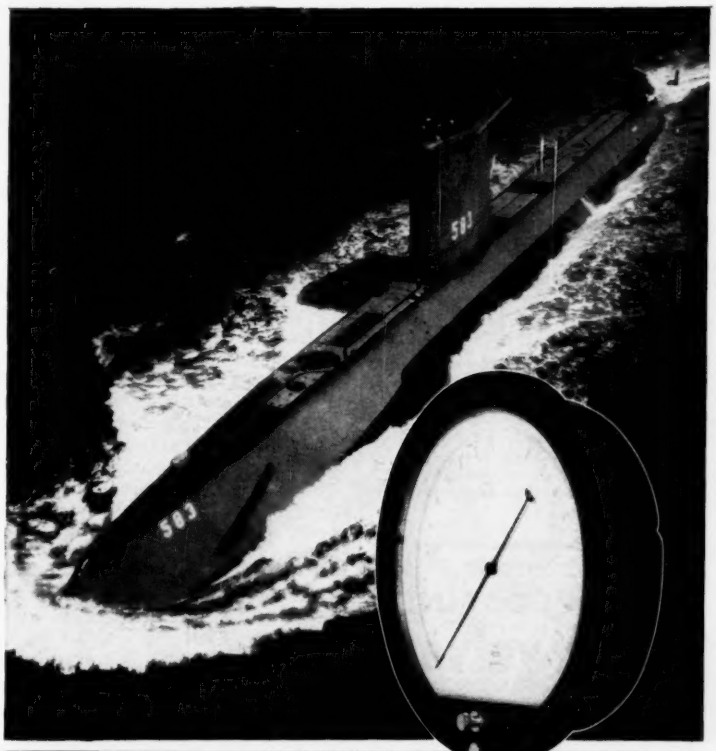
Something More Than
"COMMERCIAL INSTRUMENTATION"

Standards of accuracy for instruments used in testing reactor plants in nuclear powered submarines may be achieved only by superior design and scrupulous workmanship.

The Heise Bourdon Tube Company provided pressure gauges used in initial tests of the power plant designed for the USS Nautilus, the first atomic powered submarine.

Heise Gauges were also used during initial testing of reactor plants on the atomic powered submarines, Skipjack, Skate, Swordfish, and Sargo.

Heise Laboratories design and manufacture pressure measuring instruments for the most advanced research and development projects.



FULL SCALE READING (P.S.I.)						DELIVERY 2 WEEKS FOR MOST RANGES
OVER	15	5,000	20,000	30,000	40,000	
INCLUDING	5,000	20,000	30,000	40,000	50,000	
DIAL SIZE	PRICE F.O.B. NEWTOWN, CONN.					
8½"	$166.75	$186.75	$216.75			
12"	$190.50	$210.50	$240.50	$250.50	$260.50	
16"	$232.25	$252.25	$282.25	$292.25	$302.25	

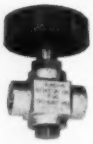
HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 121 ON READER-SERVICE CARD

3 Reasons Why

Robbins VALVES Are the Most Economical You Can Buy

1. The only valves that can be completely serviced in less than 1 minute from the front of mounting panel without removing the valve from the line!



To service a Robbins Metering & Shut-Off Valve it is only necessary to remove the handle, loosen locknut and remove barrel assembly . . . all accomplished from the front of the panel . . . no need to disturb the line connections!

2. Single barrel assembly!

For both civilian and military installations the single barrel assembly design and construction features (barrel, spindle, spindle seals, barrel seals and seat in one unit, cleaned, lubricated, sealed for oxygen service) mean practically instantaneous renewal of service without disconnecting any plumbing.

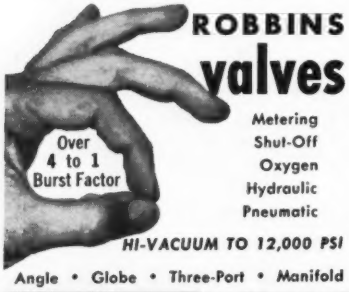
3. As many as 5000 cycles before requiring servicing!

Many Robbins Metering Valves . . . in constant use on an 8-hour a day basis for three years . . . have never required servicing, lubrication, or any parts replaced!

...And the Most Reliable!

Precision made and tested. Design capabilities, manufacturing procedures, and quality control operations at Robbins Aviation are all directed toward one objective . . . to produce a valve of the highest quality that will provide the user with the greatest reliability and the greatest economy over many years of service.

All Valves LOX Cleaned and Packaged . . . Ready for Instant Use



ROBBINS Aviation Inc.

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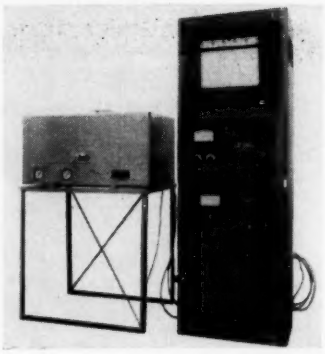
LUdlow 9-5221

CIRCLE 122 ON READER-SERVICE CARD

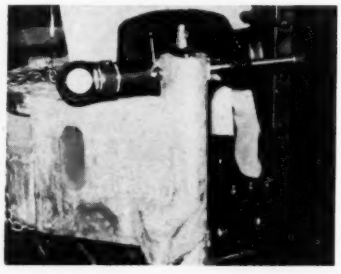
PROCESS FLAME PHOTOMETER

New Flame Photometer measures the chloride-ion content of boiler feed water with parts-per-billion sensitivity by measuring the sodium normally associated with chloride ions in it. It also measures other materials exhibiting flame emission. Consisting of two parts, an optical unit and a control panel, the optical assembly houses the sample manifold, burner, monochromator and photomultiplier. The control panel houses the high-voltage supply, amplifier, automatic standardizing system, ample sequence selector, and the recorder.—*Waters Associates, 45 Franklin St., Framingham, Mass.*



CIRCLE 266 ON READER-SERVICE CARD

PORTABLE HARDNESS TESTER

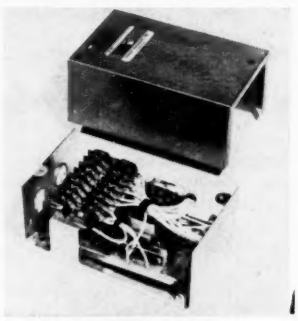


New semi-automatic Model LL Microhardness Tester with its relatively selective range of indentation loads of 25 to 1,000 grams, utilizes C-clamp brackets with varying throat sizes and can be moved from one location to another. Standard Rockwell B and Rockwell C scale tests are produced by spring loading. These springs are naturally and artificially aged.—*Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.*

CIRCLE 267 ON READER-SERVICE CARD

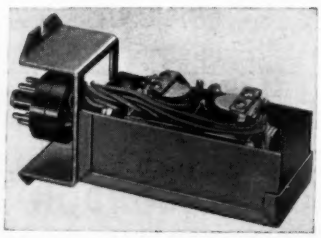
RANDOM REMOTE SELECTOR

New Random Remote Selector, Model RS-550, is for application where it is impossible or impractical to employ mechanically interlocked push buttons or other simple methods for solving remote selection problems. When any of the push-button switches is actuated, it automatically steps to and homes on the proper contact on a rotary wafer switch, making the desired circuit, and remaining in this position until it is again actuated.—*Warco Industries, 6625 Delmar Blvd., St. Louis 30, Mo.*



CIRCLE 268 ON READER-SERVICE CARD

LATCH-IN RELAY



New Latch-in Relay with plug-in mounting and hold-down clamp, designated Class 11LP, is made of two miniature telephone-type relays in a common support frame. Armatures of the two relays are mechanically interlocked. Available for d-c continuous or intermittent duty and for a-c intermittent duty. Catalog 160 gives details.—*Magnecraft Electric Co., 3350L, West Grand Ave., Chicago 51, Ill.*

CIRCLE 269 ON READER-SERVICE CARD

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SOLENOID VALVES

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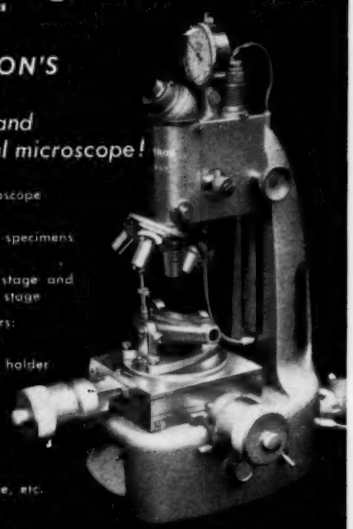
MEASURE IN 3 DIMENSIONS TO 0.0001"

with UNITRON'S Combination Toolmakers and Metallurgical microscope!



- Direct reading from microscope screws and dial indicator
- Examines polished metal specimens at 30X, 100X, 400X, etc.
- Ball bearing rectangular stage and calibrated circular rotary stage
- Three separate illuminators: substage, surface, vertical
- Inclinable work and tool holder
- Accessories include viewing screen for contour projection and optical comparison, eyepiece scales for measuring screw threads, diameters, metal grain size, etc.

Even the smallest shop can rapidly pay for this versatile instrument in time and materials saved. UNITRON Model TM, with all its features, costs about the same as the lowest priced, simple shop microscope. fab Boston only $1050

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UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.

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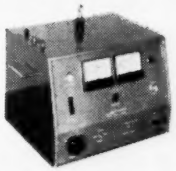
TEST INSTRUMENTS

for ELECTRICAL EQUIPMENT

Laboratory..Production..Maintenance



Voltage Breakdown

Insulation Leakage

0.02 mma to 10 ma

Test Potentials to 30 kv

Bench HYPOT® Test Sets, a-c and d-c models, have outputs to 30 kv. Separate 4½" meters for test voltage and leakage current. Wide selection of models.

Model 424 Bench HYPOT® provides 0-5000 v d-c. For testing cables, condensers, coils, transformers, motors, and assemblies. Measures leakage current from 0.1 microampere to 100 microamperes over four scale ranges. Rapid testing of capacitors with output of 5 milliamperes under short circuit. Operates from 110-120 v 50/60 c outlet with long-life selenium high voltage supply.

Net complete..... $497.50

- **Insulation Materials Tester**

  Dielectric strength determined to laboratory precision. Interchangeable test fixtures for varnishes, porcelain, tape, acetate sheet, films, tubing and cloth. Write for Bulletin, Model 4501 HYPOT® Materials Tester.

- **Insulating Oils Tester**

  New portable design, only 42 lbs., for testing insulating oils at point of application as well as in the laboratory. Test potential variable from 0 to 35 kv, with 2 kva rating. Write for bulletin Model 4505 HYPOT® Oil Tester.

- **Measure Resistance to FIVE MILLION MEGOHMS**

  VIBROTEST® megohmmeters provide direct reading measurements to FIVE million megohms and higher with electronic power supply that eliminates tedious cranking. Write for bulletin "VIBROTEST".

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  VIBROGROUND® measures resistance to ground of electronic, telephone, and power equipment. Direct reading. Operates from self-contained battery. Write for Bulletin "VIBROGROUND"®.

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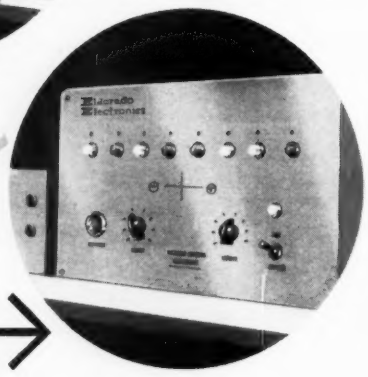
CIRCLE 125 ON READER-SERVICE CARD

How Do You Measure and Sort?

This way...

or this way...



...with Digital Display

Here are two ways of presenting accurate measurement information. One requires a scope and a skilled operator. The other—an Eldorado system—gives the result in easily read digital form. The Eldorado system can be used by unskilled personnel to give more accurate results at lower costs and, since it is a digital system, it can be adapted to automatic control production or test processes.

Two Typical Functions of Eldorado Systems:

1 **Analysis as to Size.** Eldorado has basic circuits which analyze pulse height. All that is required is a transducer capable of feeding pulses proportional to size of the physical phenomena to be measured and sorted.

2 **Analysis as to Time.** Other Eldorado systems accurately count and store the number of events occurring in any number of discrete and consecutive time intervals. Again, the only other component needed aside from the system is a transducer.

NOTE: Each Eldorado system is designed for a specific application. Eldorado will be happy to discuss yours in detail. Contact your Eldorado representative, or write us direct. You'll have a quick answer.

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Eldorado Electronics

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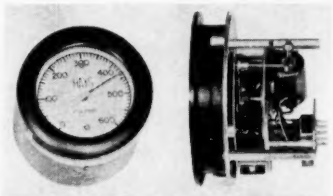
CIRCLE 126 ON READER-SERVICE CARD

RECEIVER INDICATOR

New all-electric round dial Remote Receiver, Model 731, for remote indication of gas and liquid pressure, draft, differential pressure, flow,



temperature, and liquid level, features great speed of response (2.5 sec for full scale travel or better), sensitivity of 0.1% of full range or better, accuracy for flow of ±1%; and for low, medium or high pressure, and temperature of ±2% of full range. Available in 4½", 6", and 8½"-dia. size.—*Hays Corp., Michigan City, Ind.*

CIRCLE 270 ON READER-SERVICE CARD

CENTRAL-MINUTE-REGISTER STOPWATCH

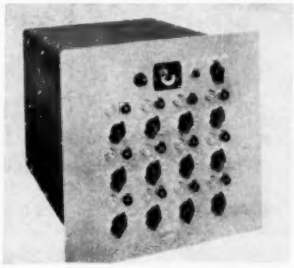
New design of Stopwatches registers the minutes on a large red circle around the central shaft, rather than on the conventional off-center circle

with a stub hand. 60 min of elapsed time can now be registered (see top watch in photo) rather than the usual 30 min. Improvement has already been incorporated in almost the full line of 66 stopwatch models.—*Heuer Timer Corp.*, 441 *Lexington Ave., New York* 17, *N. Y.*

CIRCLE 271 ON READER-SERVICE CARD

CONDUCTIVITY CONTROLLER

New automatic cycling multipoint Conductivity Controller, Model ARPT-315KA, monitors purity of return steam condensate at up to 12 seperate

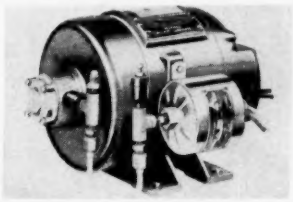


points on a single instrument. Also used to check contamination of demineralized water in rinsing operations. Includes alarm light.—*Industrial Instruments, Inc.*, 89 *Commerce Rd., Cedar Grove, Essex County, N. J.*

CIRCLE 272 ON READER-SERVICE CARD

AIR PUMP

New oil-free Air Pump for industrial processes, Model RG10470, has pre-lubricated bearings, self-lubricating thrust plates and blades, oil-free impeller parts and no seals or shaft

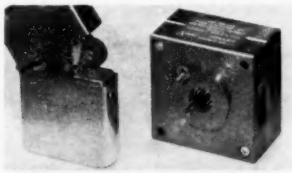


packings. Features include pressure switch which provides automatic shut-off at high pressure conditions, and automatic re-start. Rated pump capacity is 0.3 scfm at 20 psig discharge pressure with standard sea level inlet conditions. Pump displacement is 0.304 cu in/rev.—*Lear, Inc., Box* 688, 110 *Ionia, N. W., Grand Rapids, Mich.*

CIRCLE 273 ON READER-SERVICE CARD

MODULAR SPEED REDUCER

New Model 030 Modular Speed affords twenty different ratios by combining two or three modules. Four basic ratios, 5, 10, 20, and 25:1 can be

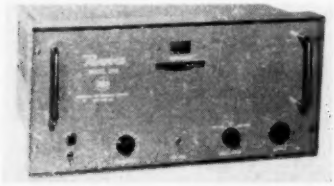


arranged to provide ratios ranging from 5:1 with a single unit to 15,625:1 by combining three units. Size: 1¾" x 1¾" x 1", weight is 4½oz. Unit can be used on a wide range of BuOrd Servo Motors.—*Link Div., General Precision, Inc., Binghamton, N. Y.*

CIRCLE 274 ON READER-SERVICE CARD

ELECTRONIC GENERATOR

New Model 250 Powertron Electronic Generator supplies 250 va of power at either a fixed frequency of 400 cps ±0.25% or a variable fre-

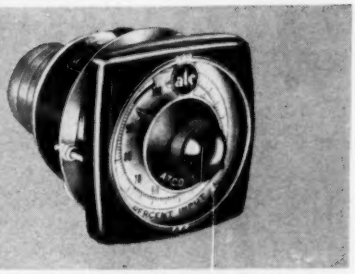


quency with a range of 350-450 cps. An input jack is also provided for output frequencies from 50-4000 cps. Output voltage is continuously variable from 0-120 v. Features include: less than 1% output distortion, better than 1% regulation from no load to full load, and the ability to be used with loads of any power factor.—*Industrial Test Equipment Co., 55 East 11th St., New York 3, N. Y.*

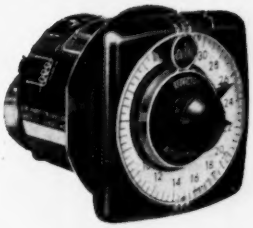
CIRCLE 275 ON READER-SERVICE CARD

TIMERS

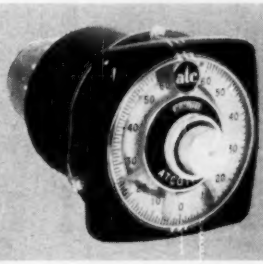
Atcotrol Percentage Timers accurately handle on-off operations for all types of electrically heated equipment up to 25 amp. loads. End power waste. UL approved. **Series 304**



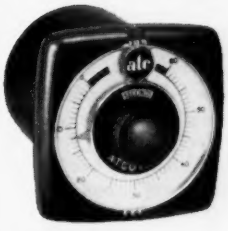
Atcotrol Miniaturized Reset Timers control AC or DC loads within variable timed intervals or sequences of ¼ of 1%. Six basic current arrangements provide infinite combinations for automation functions. FM approved. **Series 305**



Atcotrol "Duo-Set" Timers control two independently adjusted load circuits for on-off cycling. Set desired delay between de-energizing of forward and energizing of reverse. End interrupting timer motor, straining of mechanism. **Series 306**



Atcotrol Transistor Timers are new types for long life and simplicity in short interval, highly repetitive timing cycles. Conservatively rated at 3 million operations. Six timing ranges 1.5 seconds to 150 seconds. Rated 15 amps @ 115 VAC, 10 amps @ 230 VAC, 4 amps @ 115 VDC. **Series 308**



IF IT'S A TIMING PROBLEM, SEE ATC. Wide product selection includes cam timers, automatic reset timers, revolution counters, electronic timers, impulse counters, transistor timers, many others.
Special timers and counters designed to your requirements.

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CIRCLE 127 ON READER-SERVICE CARD

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DC driven
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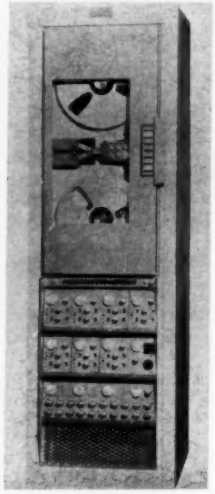
CIRCLE 128 ON READER-SERVICE CARD

VIDEO RECORDER/REPRODUCER

New CM-100 Video Band Recorder/Reproducer system records both analog and pulse signals, yet its cost is in the standard instrumentation price range. At any one of its six speeds,



it is claimed to be capable of twice the frequency response of similar equipment previously produced. Overall bandwidth is 400 cps to 1.0 Mc per track. The 7-track system is packaged in a single, standard size rack. 6 speeds range from 7½ ips to 120 ips with instantaneous speed control; ½" tape is used.—*Mincom Div., Minnesota Mining and Mfg. Co.*, 2049 *S. Barrington Ave., Los Angeles* 25, *Calif.*

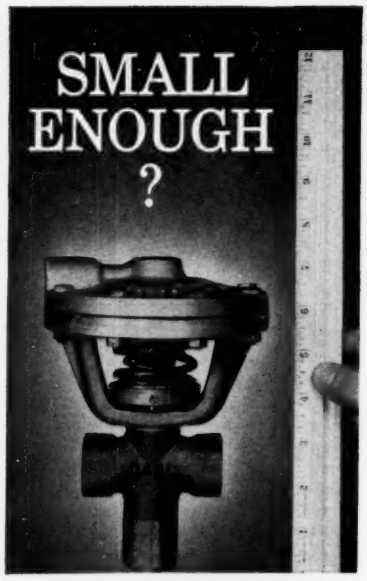
CIRCLE 276 ON READER-SERVICE CARD

ELECTRONIC COUNTERS

Two new Electronic Counters, Models 521D and 521E, measure frequency and random events per unit of time, and automatically display

results on an in-line 5-place readout (Model 521E) and a 4-place readout (Model 521D) respectively. Frequency range is 1 cps to 120 kc. The 521E has a crystal time base assuring accuracy of 0.01% ±1 count; the 521D's accuracy is controlled by power line frequency (typically 0.1%) ±1 count. —*Hewlett-Packard Co.*, 275 *Page Mill Rd., Palo Alto, Calif.*

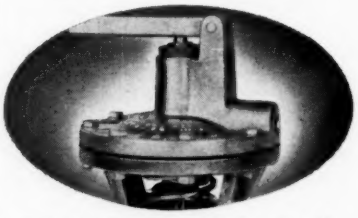
CIRCLE 277 ON READER-SERVICE CARD



DAHL 4000 Series Valves are approximately 7" in height — which offers optimum utility, size and price.

The 4000 Series features:

- Direct or Reverse Acting Operators
- Manual Reset Operators
- (Other Operators Available.)



Six body types are available in ⅛" to ½" NPT sizes:

No. 100 – 2-way with "O" ring stem seal
No. 105 – 2-way with Teflon packing
No. 110 – 3-way with atmospheric bleed
No. 115 – 3-way with Teflon packing and piped exhaust
No. 120 – 3-way with "O" ring seal and piped exhaust
No. 125 – 3-way with "O" ring seal (all ports closed in mid position)

Write for complete details today

GEORGE W.
DAHL
COMPANY, INC.

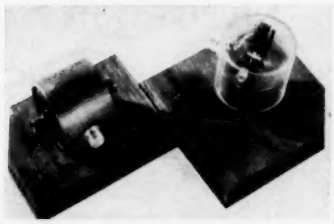
86 TUPELO STREET
BRISTOL, RHODE ISLAND
CLifford 3-9500

VALVES AND CONTROLS FOR THE COMMUNICATIONS, PROCESS, AIRCRAFT AND MARINE INDUSTRIES

CIRCLE 129 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

New Potentiometer Pressure Transducer, Series TI-P-MH, offers pressure ranges from 0 to 100 psia or psig, and employs a new patented light wiper arm which achieves contact



pressure by means of an electromagnet. Specifications include—linearity: ±0.75%; resolution: 0.3%; hysteresis: 0.6%; repeatability: ±0.3%. Absolute and differential pressure measurements of non-corrosive fluids and gases are afforded. —*Physical Sciences Corp. (formerly Technical Industries Corp.), affiliate of Packard-Bell Electronics, 389 North Fair Oaks, Ave., Pasadena, Calif.*

CIRCLE 278 ON READER-SERVICE CARD

RECTIFIER POWER SUPPLIES

New line of semiconductor Rectifier Power Supplies for the production and testing of tantalum and other electrolytic capacitors utilizes newly developed, non-aging silicon or selenium elements, and vernier-controlled automatic programming for simple and precise adjustment of completely automatic formation process cycles.—*Sel-Rex Rectifier Div., Meaker Co., Subs. of Sel-Rex Corp., Nutley, N. J.*

CIRCLE 279 ON READER-SERVICE CARD

COUNTER/TIMER

New one-megacycle counter timer, Model 361 Apti-Meter (for actions-per-time-interval), is a transistorized decade counter which performs all the functions of a counter, frequency meter, time-interval meter, secondary

frequency standard, period counter, and ratiometer, without the need for accessory equipment or plug-ins. High counting accuracy is achieved through use of a transistorized, crystal-controlled clock. It features Nixie in-line readout, small size, portability, and low power requirements.—*Transistor Specialties, Inc., Terminal Dr., Plainview, L. I., N. Y.*

CIRCLE 280 ON READER-SERVICE CARD

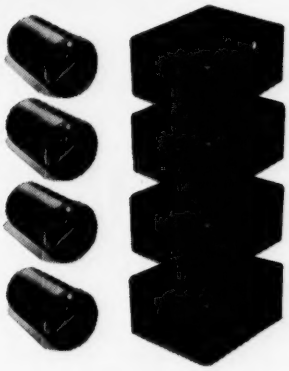
BH100 Series

MILLI-V-METER®

The instrument with the TAPE-SLIDEWIRE

for Test Cells
Ground Support
Flight Deck
Telemetry

...to accurately indicate



TEMPERATURE
R.P.M.
PRESSURE
FLOW

1/10 THE SIZE, 10 TIMES THE ACCURACY
(of standard instruments)!

These 3x5" and 3"-dia. instruments are used by many manufacturers and laboratories to measure every parameter... in missile, aircraft or ground support. Ideally small and matched for panel uniformity, they offer reading of the individual phenomenon or of many states through selector switching... with fast response. Every measurement exhibited on the counter is a definitely calibrated value. Component density of the 3"-dia. BH183 is the highest obtainable combined with ultimate instrument accuracy. Manufactured to MIL-E-5272 and MIL-I-6181 specs.

FEATURES:

1) Accuracy 1 part in 1000.
2) Laboratory precision for the military or industry.
3) Compatibility with any transducer —AC or DC.
4) For strain gage, linear differential transformer, thermocouple, thermistor, resistance thermometer, pulse or variable frequency circuits or systems.
5) Available with re-transmitting slidewire.
6) Every scale unit a calibrated value.
7) Operates directly from 60- or 400-cycle power.

Produced by the makers of JETCAL® jet engine Analyzer... in worldwide military and airline use!

Full information is available for the asking!

B & H INSTRUMENT CO., INC.

3479 West Vickery Blvd., Fort Worth 7, Texas

Sales-Engineering Offices:
ATLANTA, GA., COMPTON, CAL., DAYTON, OHIO, VALLEY STREAM, L.I., N.Y., WICHITA, KAN.
TORONTO, ONT. *(George Kelk Ltd.)* MITCHAM, SURREY, ENGLAND *(Bryans Aeroequipment Ltd.)*

CIRCLE 130 ON READER-SERVICE CARD

GAUSSMETER

New Precision Rotating Coil Gaussmeter, Type 820, for measuring d-c magnetic fields, uses rotating probe coil to develop an a-c voltage proportional to the magnetic field and

compares this against the voltage from a local reference generator in a null-deflection circuit. Specifications include range of 0-10,000 gausses using reference generator, 0-120,000 gausses with meter only. Accuracy is 0.1% between 1000 and 10,000 gausses using reference generator. Probe dimensions are ¼" dia, 17" lg, exclusive of motor and handle.—*Rawson Electrical Instrument Co., 112 Potter St., Cambridge, Mass.*

CIRCLE 319 ON READER-SERVICE CARD

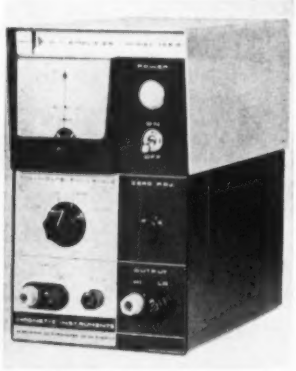
READOUT OSCILLOGRAPH

New Model 607 Oscillograph provides for the recording of up to 50 channels of test data on a 12"-wide record with speeds variable from 0.05 to 170"/sec. Other features include: Galvanometers with flat response to 6000 cps; forward and reverse record drive; built-in magazine; and daylight loading.—*Midwestern Instruments, Box 7186, Tulsa, Okla.*

CIRCLE 320 ON READER-SERVICE CARD

LOW-LEVEL D-C AMPLIFIER

New Low-Level D-C Amplifier, Model 759-6, which accepts signals from 5 μv to one v, features a high

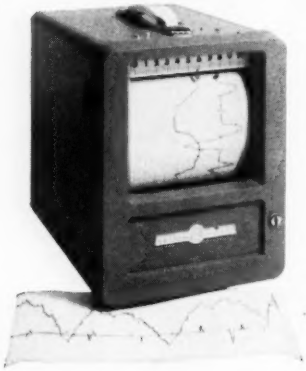


degree of stability and low noise, indicates on its own panel meter (Model 759-5 is without meter) or records on a meter-type recorder. Accuracy is 0.25% and stability is 5 μv.—*Magnetic Instruments Co., Thornwood, N. Y.*

CIRCLE 321 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

Something important has been added . . .



5. THE NEW G-22 IS

2 CHANNEL

Two channels mean more than just an added trace. They make the G-22 a correlator of simultaneous variables—any pair you choose. And among two-channel recorders, the G-22 is the most practical yet—lighter, more compact, more versatile and lower in cost than any other of its type.

Interchangeable plug-in input chassis; 1% limit of error and one second full-scale balancing time; adjustable range from 0-10 mv to 0-100 mv; dual chart speed standard; four speeds optional; portable or panel-mount versions; weight 35 pounds; price $975. Full specifications available. Write the Instrument Division.

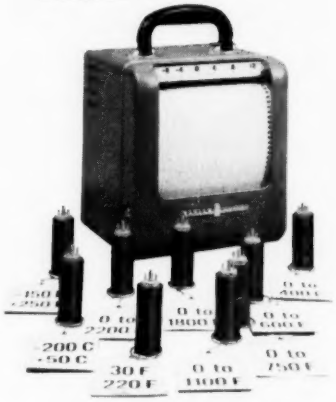
VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 131 ON READER-SERVICE CARD

VARIAN
Temperature
RECORDERS

Most versatile and useful because . . .



6. THEY'RE PORTABLE AND

MULTI-RANGE

Nine plug-in elements adapt this G-11A thermocouple recorder to any range—cold as liquid nitrogen, hot as 2200°F, or as specific as 30° to 220°F. Being portable, it goes wherever there's temperature to measure—research in the lab, checkout in the factory, or troubleshooting in the field.

The temperature recorder is a Varian G-11A with T-2 input chassis which has automatic reference junction compensation and plug-in range elements as shown. Other input chassis convert the recorder to general use. Fahrenheit or Centigrade charts available. For full details, write Instrument Division.

VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 132 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

Preferred for real differences, for example . . .

7. ADJUSTMENTS MAKE THEM

VERSATILE

Zero is adjustable—left, right, center, or any uneven division of the chart to fit each particular use. Also, ranges from 0-9 millivolts to 0-100 volts. Such options as temperature recording are provided by interchangeable chassis and matching charts and scales.

1% accuracy; 1 or 2½ seconds full-scale balancing time; portable, bench top or panel-mounted versions; single channel units weigh 15 pounds, dual channel 35 pounds; prices from $365; wide range of speeds and other options described in Varian literature. Write the Instrument Division.

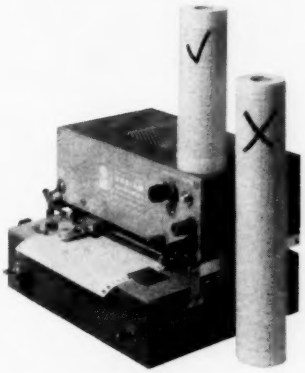
VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 133 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

A preferred size for many uses because . . .



8. FIVE-INCH CHARTS ARE

ECONOMICAL

A 50% savings in paper can mean hundreds or thousands of dollars in the life of a recorder. Five-inch charts are handier too for notebooks, reports or files. And in round-the-table conferences, smaller charts can be set side by side, giving more data and less clutter.

1 & 2 channel versions use same 5-inch chart paper; 1% limit of error and 1 or 2½ second full-scale balancing time; chart speeds from ⅛ inch per hour to 16 in./min.; prices from $365; numerous options described in Varian literature. Write the Instrument Division.

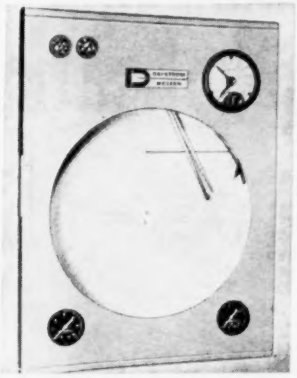
VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 134 ON READER-SERVICE CARD

ELAPSED TIME CONTROLLER

New Elapsed Time Controller, Model 7003, provides timed automatic regulation of either temperature or

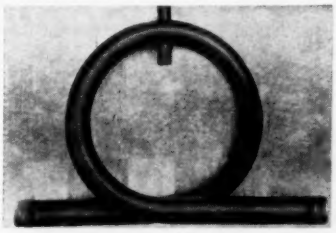


pressure in batch type operation. Ranges are from −100°F or 30″ Hg vac to 1000°F or 7500 psig. All classes of thermal systems are available to suit each individual temperature application. The control signal is pneumatic.—*Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*

CIRCLE 281 ON READER-SERVICE CARD

PRIMARY FLOW-ELEMENT

New Primary Flow Element is a pipe loop of the centrifugal head type which, by changing the direction of the fluid flow, creates a pressure differential across the flow section. Rate



of flow can be calculated from the pressure differential as accurately as the dimensions of the element can be measured. Element eliminates completely the potential error associated with the empirically determined coefficient of discharge, K. Individual calibration is not necessary.—*Fluidynamics Co., 1853 S. 8th Ave., Monrovia, Calif.*

CIRCLE 282 ON READER-SERVICE CARD

HYDRAULIC PEAK PRESS GAGE

New hydraulic Peak Pressure Gage is for use by service, field, and production personnel to troubleshoot and correct hydraulic systems that are subjected to excessive transient pressures. Instrument contains in one package a pressure pickup, an amplifier and a peak detector, followed by a large meter. Full scale (0-4000 or 0-10,000 psig) output is 40 v and frequency response is 0-1000 cps.—*Hydel, Inc., 223 Crescent St., Waltham 54, Mass.*

CIRCLE 283 ON READER-SERVICE CARD

Name Your Application!

Do It Better With *ThermoElectric* *Thermocouple Extension Cables and Wires*

You can obtain Thermo Electric thermocouple extension wire and cable in the widest variety of size, insulation, type and calibration, for your application—with prompt delivery of all standard materials.

New on the stock list, is the time and labor saving "Thermo-Cable," from 6 to 56 matched pairs of I.S.A. color-coded thermocouple leads, individually insulated in PVC—collectively wrapped in "Mylar" aluminum-backed tape—with a tight-fitting PVC outer sheath. "Thermo-Cable" is practically impervious to moisture, abrasion, temperature, gasses and chemicals. Saves you the time, cost and effort of pulling individual wires through conduit.

Individual or duplex thermocouple and extension wires are available in all standard calibrations—many in gages from 14 to 40—insulated with Polyvinyl Chloride, cotton lacquer, Nylon, Teflon, Fiberglass, Asbestos or combinations of these materials. Metallic overbraids of stainless steel and other high-temperature materials provide extra mechanical protection and shielding.

"Ceramo", Thermo Electric's metal-sheathed ceramic insulated thermocouple wire is used for extra-high temperature and nuclear applications.

Thermo-Electric also supplies thermocouple wires to meet Mil-Spec requirements.

For information on selecting the right wire for your application,

write today for Bulletin 32-W5-12

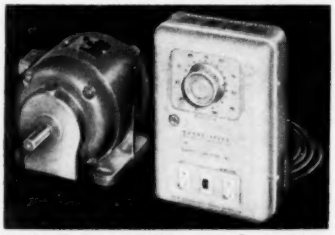
Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

CIRCLE 135 ON READER-SERVICE CARD

VARIABLE SPEED DRIVES

New line of Motor Controllers for industrial power applications has units which operate off 115 v/60 cps/1-phase supply, and provide adjustable d-c voltages for driving d-c shunt motors. Manufactured in three sizes:

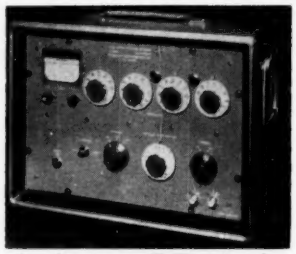


"Junior" for 1/100 to ⅛-hp motors; Size I for ¼-, ⅓-, and ½-hp motors, and Size II for ¾-, 1-, and 1½-hp motor. Regulation is approximately ±4% of base speed, speed range to 50:1, instantaneous response, with vernier speed adjustment. High-temperature silicon rectifiers provide a 300% increase in surge safety factor.—*Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.*

CIRCLE 284 ON READER-SERVICE CARD

LOW CAPACITY BRIDGE

New Bridge Model 1342, affords three terminal capacity measurements from 0.002 $\mu\mu$f to 1,000 $\mu\mu$f with accuracy of ±0.2%. Completely self-contained instrument is valuable for measuring tube interelectrode capac-



ity, circuit strays, R-F network components, etc. Extreme resolution makes temperature coefficients and small capacity changes easy to measure. Based on a transformer ratio-arm bridge operation at one kc, this technique has the advantage of requiring only one capacitive and resistive standard which can be selected for extreme accuracy and stability.—*Marconi Instruments, Inc., 111 Cedar Lane, Englewood, N. J.*

CIRCLE 285 ON READER-SERVICE CARD

MULTITRACER UNIT

New portable electronic Multitracer Unit which presents and stores consecutive sweeps at equal pre-selected intervals, is a combined attenuator, gate amplifier, and storage-counter designed to be placed between the signal source and the regular Memoscope oscilloscope input.—*Hughes Industrial Systems Div., International Airport Station, Los Angeles 45, Calif.*

CIRCLE 286 ON READER-SERVICE CARD

CONVERTS A DC CONTROL SIGNAL TO A PROPORTIONAL VALVE-ACTUATING AIR PRESSURE

and prevents pneumatic freeze-ups with an integral heater

The Swartwout Type P2R Power Relay is a simple null-balance device. By balancing a magnetic force against the air-loading pressure, it maintains an accurate linearity between electrical input and pneumatic output. It has no vacuum tubes, journal bearings or other friction surfaces. There is a high-capacity booster relay in the pneumatic section to make valve actuation extremely fast. And, if you want, a heater can be included to prevent cold, moist air from freezing the pneumatic block.

You have only one field adjustment to make on the Power Relay: Zero. The range (1—5 milliamperes DC input; 3—15 psi output) is permanently adjusted at the factory. And the unit is temperature compensated for accurate calibration over a wide ambient range. If desirable, you can change the Power Relay from direct to reverse action.

One customer chose the Power Relay because of its superior sensitivity, linearity and reproducibility. Another uses the heater model on a cryogenic-fluid application.

You'll probably have your own good reasons after reading Bulletin A710-B. *Write the Swartwout Division, Crane Co., Hooksett Industrial Park, Manchester, New Hampshire.*

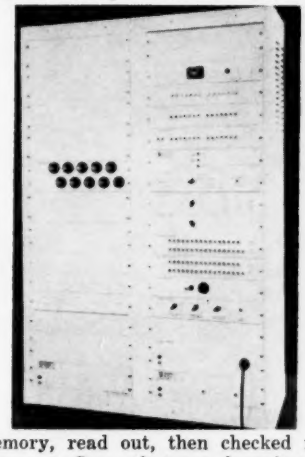
SWARTWOUT DIVISION CRANE CO

. . . world leader in electronic process instrumentation

CIRCLE 136 ON READER-SERVICE CARD

MEMORY SYSTEMS TESTER

New Memory Exerciser, automatically locates and counts defects in core memory systems. One of a variety of checkerboard patterns is read into the

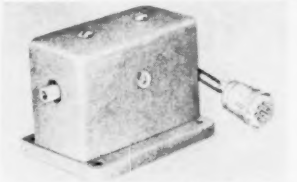


memory, read out, then checked for accuracy. Cores that are dropping or picking up "ones" light an error bulb and are counted. The machine can either stop on the error to allow the operator to note the defects location, or it can pause on the error and then continue.—*Digital Equipment Corp., Maynard, Mass.*

CIRCLE 287 ON READER-SERVICE CARD

POSITION TRANSDUCER

New Model DP-33 Position Pickoff, a position-sensitive Transducer incorporates a linear variable differential transformer as its basic sensing element, and features high stepless



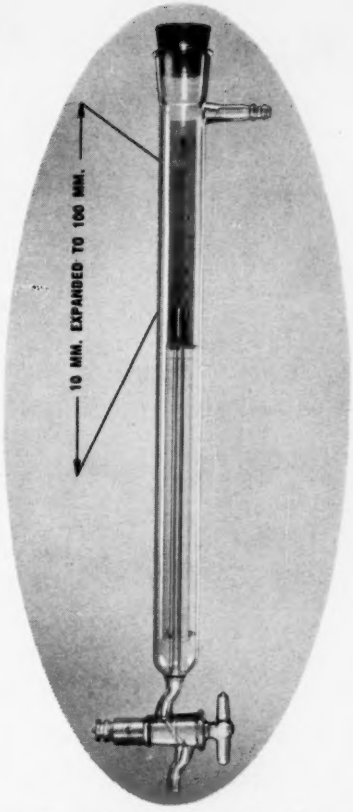
output, external zero adjustment, and infinite resolution. Applications include measurement of beam deflection, thickness, strain and elongation, surface quality of materials in motion, and thermal expansion of metals. Linearity is 1% (full scale). Output voltage for nominal 6.3-v input ranges is from 0.250 at 60 cps to 1.6 at 20,000 cps.—*Schaevitz Engineering, Route* 130 *& Schaevitz Blvd., Box* 505, *Camden, N. J.*

CIRCLE 288 ON READER-SERVICE CARD

SUBMIN PRESSURE SWITCH

New sub-miniature, adjustable Pressure Switch weighs slightly more than an ounce, and its volume is less than one cu in. Performance up to 200 psig under vibration, shock, and acceleration test conditions exceeds MIL-E-005272B specs.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 289 ON READER-SERVICE CARD



10-Time Magnification Simplifies 0-10 mm. Pressure Measurements!

CARTESIAN MANOMETER

gives absolute and differential readings

RANGE:	**0-10 mm. Hg.**
GRADUATION:	**0.1 mm. Hg.**
ACCURACY:	**1% of full scale**
CONSTRUCTION:	**All glass**

For the difficult 0-10 mm. region of absolute pressure measurement, where ordinary manometers are too coarse and McLeod gauges too inconvenient. This simple gauge magnifies the pressure readings by a factor of 10, so that 0 to 10 mm. of Hg. appear on a scale of 100 mm. in length.

Adaptable for differential or absolute readings by means of a stopcock; can be read continuously and directly.

Exceptionally useful for vacuum distillations, oven drying, accurate differential pressure measurement, flow measurement, etc.

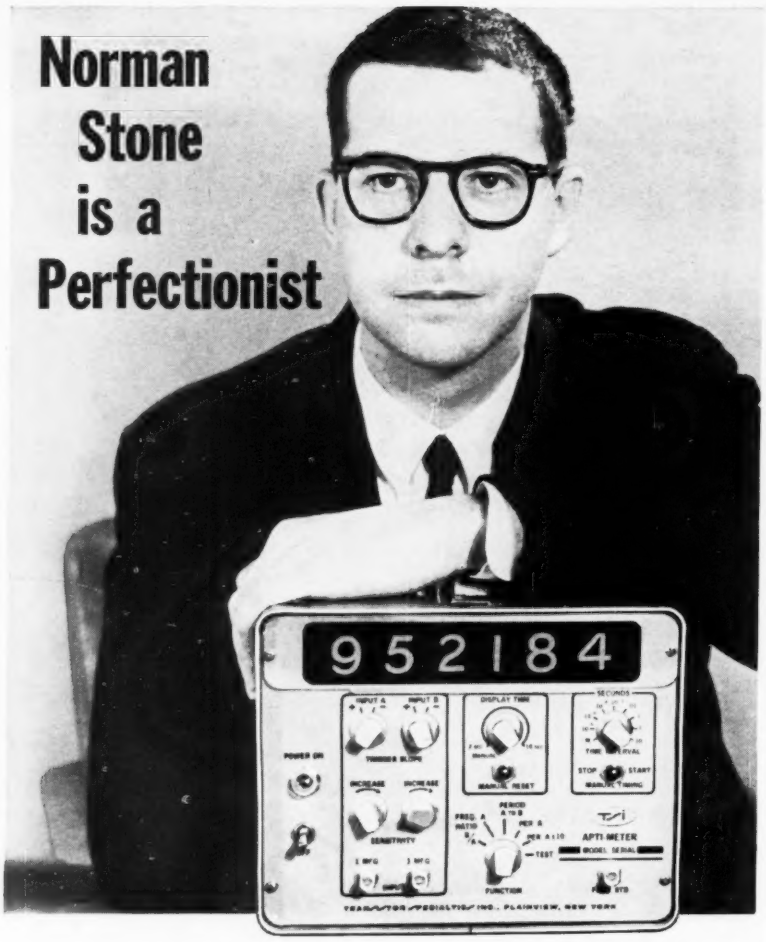
See Your Local Laboratory Supply Dealer

VG 1500...Cartesian Manometer complete and ready for use, but without mercury..**$29.90 ea.**

MANOSTAT *Corporation*

26 N. MOORE ST. • NEW YORK 13, N.Y.

CIRCLE 137 ON READER-SERVICE CARD



. . . from KNOBS to NOR-LOGIC!

We custom-designed the wrought-aluminum knobs used on the Model 361 APTI-METER* especially for our new class of ultra-compact transistorized digital instruments. A detail, perhaps, but our Chief Electronic Engineer, Norman Stone, is a perfectionist.

Norm and his staff have worked for over 3 years to bring the counting, timing, amplifying, and gating circuits in the new 360 Series to their present state of **sophisticated simplicity.**

For example, the use of resistor-NOR-logic decoding in the Decade-to-Nixie link eliminates 240 diodes used in other counters. Think of the added reliability! (The Model 361 is guaranteed for 5 years.)

May we send you literature on our APTI-METERS* before you do something regrettable . . . like buying an **old-fashioned** counter?

**APTI-METER® is our registered trade-mark for an ACTIONS-PER-TIME-INTERVAL meter. Model 361 counts from 0-1MC, has crystal-plus-oven stability of 0.3ppm/week, IN-LINE NIXIE READOUT, and identical-twin, high-impedance, high-sensitivity, amplifiers. Literally dozens of uncommonly satisfying features.*

TSi TRANSISTOR SPECIALTIES INCORPORATED

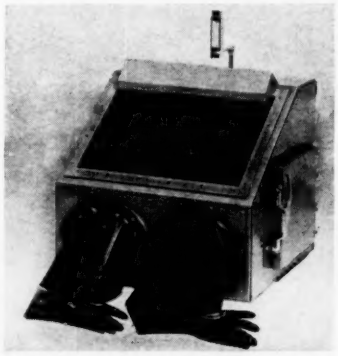
Sophisticated Digital Instrumentation

TERMINAL DRIVE, PLAINVIEW, NEW YORK

CIRCLE 138 ON READER-SERVICE CARD

MODULAR DRY-BOX

New Modular Dry-Box, Catalog No. 3814, features new easy-view angular construction, removable ends for additional units, parts gasketed with

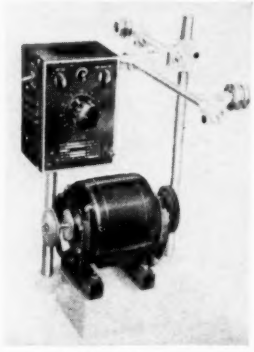


closed-cell neoprene gasket material, and tempered safety glass. Includes fluorescent lights, purge meters, one pair of neoprene gloves, a sweep tube, and large rubber feet for table operation.—*Forma Scientific, Inc., Box* 649, *Marietta, Ohio.*

CIRCLE 290 ON READER-SERVICE CARD

VARIABLE SPEED MOTOR DRIVE

New Motor Drive Unit which provides a continuously variable spindle speed from 0 to 4000 rpm includes a



reversing switch and a separate switch for controlling a coolant pump. A ⅛-hp double-ended motor is mounted on a base provided with an adjustment for belt tension.—*Louis Levin & Son, Inc.,* 3610 *So. Broadway, Los Angeles* 7, *Calif.*

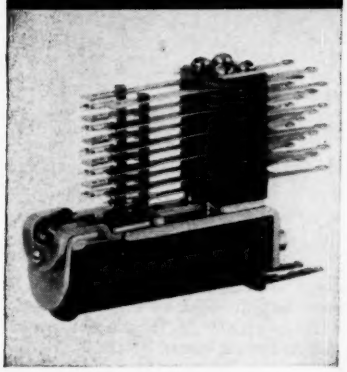
CIRCLE 291 ON READER-SERVICE CARD

DIG/AN CONVERTER

New, miniaturized Digital-to-Analog Converter, Model DAC-94, produces a d-c output proportional to the input repetition rate. A constant current generator, it will deliver 0.01 μamp/pulse/sec when used with supply voltages of approx. 12 vdc. Linearity of the converter is ±2% for output voltages not exceeding 20 mc.—*Transformer-Electronics Co., Industrial Park, Boulder, Colo.*

CIRCLE 292 ON READER-SERVICE CARD

"Telephone Quality"
Stromberg-Carlson
RELAYS



...to meet your electromechanical switching needs

These are the very same twin-contact relays proven outstandingly successful through many years of precise, exacting operation in the telephone industry.

The following regular types are representative of our complete line:

Type A: a general-purpose relay with up to 20 Form "A" spring combinations.

Type B: a gang-type relay with up to 60 Form "A" spring combinations.

Type BB: accommodates up to 100 Form "A" spring combinations.

Type C: two relays on the same frame. A must where space is at a premium.

Type E: same characteristics as the Type A, plus universal mounting arrangement. Interchangeable with many other makes.

Types A, B and E are available in high-voltage models (insulation withstands 1500 volts A. C.) for test equipment and other high-voltage applications.

Details and specifications are in our complete relay catalog, available on request. Write to Telecommunication Industrial Sales.

STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS
113 Carlson Road • Rochester 3, N. Y.

CIRCLE 139 ON READER-SERVICE CARD

INPUT SCANNERS

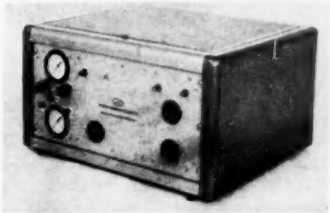
New transistorized series of input scanners includes Model 260 which sequentially connects up to 100 single-pole channels to the digital voltmeter for measurement, Model 261 for 200 single-pole channels, and Model 262 for 100 double-pole channels. All three provide channel identification for the data recorder. All logic functions are

performed by semiconductors instead of relays; and control functions are executed by transistors, diodes and high-quality relays. Heavy-duty stepping switches with gold-plated contacts and extremely high insulation resistance are used for maximum reliability. Control is remote or manual. Channel identification is automatically recorded on the data printer and displayed in the readout by 1"-high, illuminated numerals.—*Non-Linear Systems, Inc., Del Mar, Calif.*

CIRCLE 293 ON READER-SERVICE CARD

DIG PRESSURE CALIBRATOR

New fully-automatic complete calibration of a pressure instrumentation system is performed by measuring pressure in a reservoir by the Secondary Pressure Standard, the output of which is a precision frequency. This



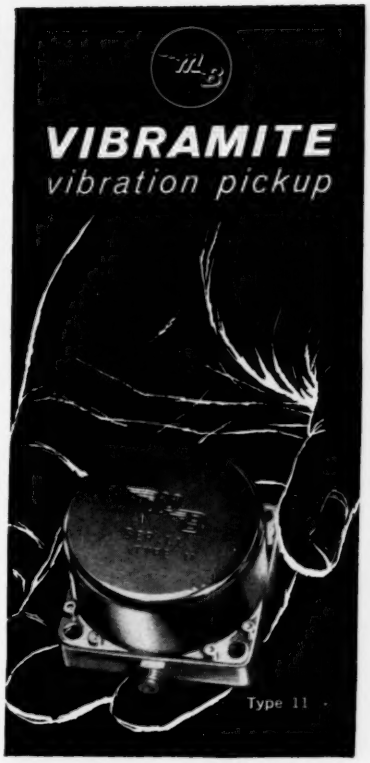
frequency is compared in the Wiancko Frequency Comparator with a selected reference frequency. The output of the comparator, indicating the magnitude and direction of the difference in frequencies, regulates the pressure in the reservoir. Accuracy is 0.05% full scale. Details in Data Sheet 160-694.—*Wiancko Engineering Co., 255 N. Halstead, Pasadena, Calif.*

CIRCLE 294 ON READER-SERVICE CARD

ALLOY-SHEATHED T/C

New line of Xactpak, alloy-sheathed, ceramic-insulated Thermocouples is made in single or multiple-pair construction to precise specifications from all common alloys, insulations, and calibrations plus "exotic" materials for very high temperatures. It can be obtained as wire or fabricated into complete assemblies with plugs, fittings, waterproof heads, and a variety of hot and cold end terminations.—*Claud S. Gordon Co., 3000 South Wallace St., Chicago 16, Ill.*

CIRCLE 295 ON READER-SERVICE CARD



Special eddy current damping gives flat response

The MB Vibramite is the only damped vibration pickup available with a flat response curve over its entire operating range.

Other highly desirable features include extremely small size, light weight and omnidirectional use.

Check these specifications:

Frequency range	20-2000 cps
Sensitivity	96.3 mv/in/sec. (Calibrated ±1% at 100 cps into 2 megohm load at 80°F)
Size	1" x 1.42"
Weight	2.75 oz
Natural frequency	15 cps
Damping	Eddy current (nominal .65 of critical)
Acceleration output limit	50 g maximum (minimum limited only by recording equipment)
Max. shock without damage	1000 g

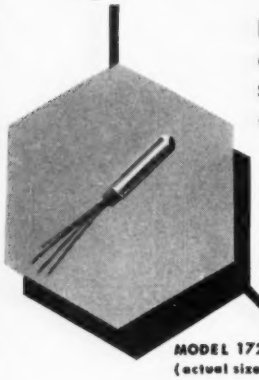
Complete technical details in Bulletin 112A. Write . . .

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1061 State Street, New Haven 11, Conn.

CIRCLE 140 ON READER-SERVICE CARD

Resistance Thermometers by REC.....

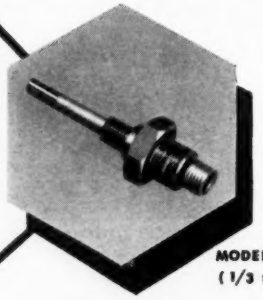
REC specializes in platinum resistance thermometers of exceptional stability and high calibration accuracy.



MODEL 172
(actual size)

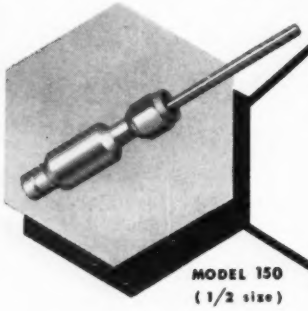
MODEL 172 series is a miniature element encased in a platinum-rhodium tube, useful from −260 to 750° C or up to 1100 C for short term use, and having a resistance of 100 ohms at 0° C, with other values available. It can be cemented or clamped to a surface, inserted in a hole, or molded into a body.

MODEL 152 probe features open platinum wire supported at intervals, resulting in extremely fast response and excellent thermal isolation between the element of the probe and the head of the probe. It is primarily intended for gases at moderate and low velocities, useful from −260 to +260° C or higher.



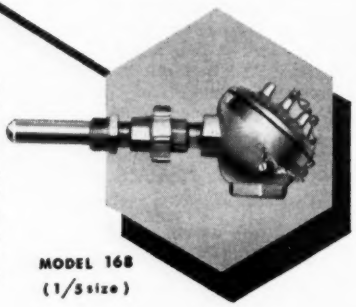
MODEL 152
(1/3 size)

MODEL 150 probe features a miniature element, only 0.160 OD outside the guard tube. It is useful from −260° C up, and finds wide applications in LO_2 and LH_2, and is available with various immersion lengths and is normally mounted by a flare fitting.



MODEL 150
(1/2 size)

MODEL 168A series probe uses a precision platinum resistance sensing element which is fully supported by a ceramic insulation. The element is protected by a stainless steel guard tube with additional support at the element tip for maximum protection to flow. The temperature range is +700° F to −435° F, and has a normal resistance of 1380 ohms at 0° C.



MODEL 168
(1/3 size)

Write for further information . . . .

REC

ROSEMOUNT ENGINEERING COMPANY

DEPT. MR-1

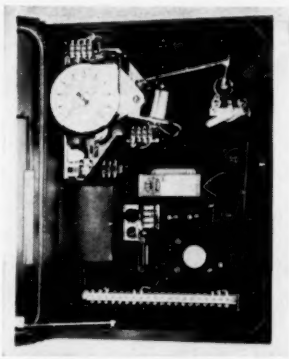
4900 West 78th St. Minneapolis 24, Minn.

We also make a wide variety of temperature probes for airplanes, missiles, rockets

CIRCLE 141 ON READER-SERVICE CARD

TRANSDUCER

New Dyna-Servo Transducer; a high-precision, high-torque, electronic transducer for converting a measurement of pressure, liquid level, temperature, mechanical motion, etc.,



into a shaft position; uses an amplifier to operate a balancing motor which provides plenty of torque for precise positioning of encoder, slidewire contact, or other device. Standard accuracy is ±0.25% of span.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 296 ON READER-SERVICE CARD

BIN/DEC READOUT UNIT

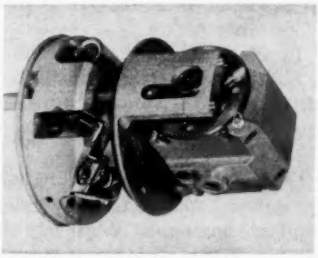
New binary Transistorized Nixie Tube Drivers, in the TND-BCD Series, are completely self-contained including drive and decoding circuitry.

Models are available for 1-2-4-8, excess-3, tertiary, biquinary, or other 4-level binary codes.—*Transistor Electronics Corp.,* 3357 *Republic Ave., Minneapolis* 26, *Minn.*

CIRCLE 297 ON READER-SERVICE CARD

MINIATURE ELECTRIC GYRO

New miniature electric Free Gyro, Type PHU, has 2° of freedom. Scors-



by Drift is 1°/min maximum, with outer gimbal readout.—*Greenleaf Mfg., Div. of Mandrel Industries, Inc.,* 7814 *Maplewood Industrial Court, St. Louis* 17, *Mo.*

CIRCLE 298 ON READER-SERVICE CARD

MOISTURE TESTER

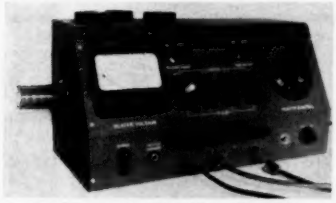
New Model 277 Moisture Teller is a low-cost unit primarily for intermittent duty where fast drying is important. Determining of moisture con-

tent of sand, ceramics, textiles, chemicals, paper and pulp products, etc. Claimed to reach a preset drying temperature faster than any similar unit in its field today.—*Harry W. Dietert Co.*, 9330 *Roselawn Ave., Detroit* 4, *Mich.*

CIRCLE 299 ON READER-SERVICE CARD

INTEGRATED TEST UNIT

New Thermion Integrated Test Unit Model B210, combines in one unit the functions of supplying variable power to several thermions, and

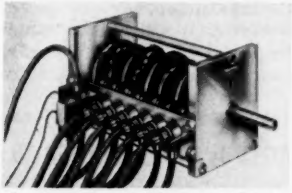


monitoring and selecting the internal test points in any of the thermions under evaluation. Bulletin 210-10-9 gives details.—*Research Council, Inc.*, 1062 *Main St., Waltham* 54, *Mass.*

CIRCLE 300 ON READER-SERVICE CARD

SEQUENCE PROGRAMMER

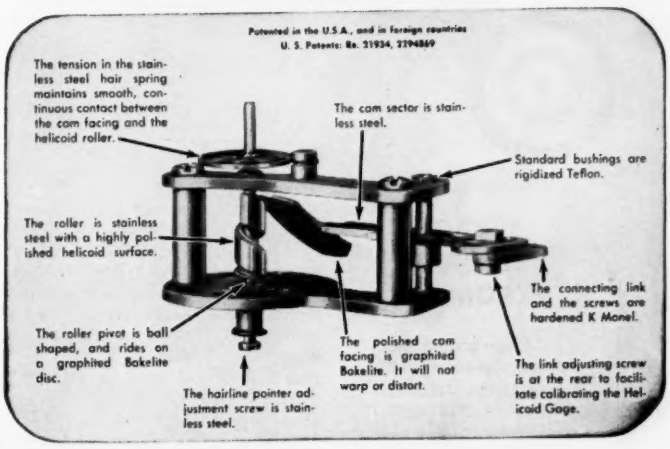
New pneumatic-electrical Minimatic Programming Unit for precise control of automatic tooling and work operations has eight easily altered



standard cams which are said to fill majority of automation requirements. Special cams with degree of rotation cuts other than standard also are available at low cost. Unit can be driven by any power source supplying a minimum of 10 in-lb of torque.—*Clippard Instrument Lab., Inc.*, 7390-*P Colerain Rd., Cincinnati* 39, *Ohio.*

CIRCLE 301 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2794869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

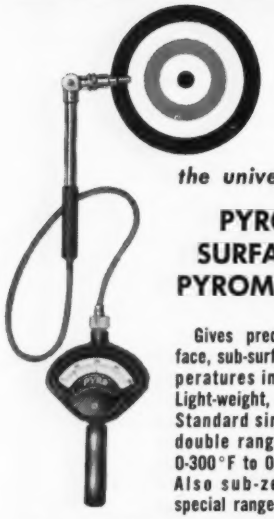
ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 142 ON READER-SERVICE CARD

UNEXCELLED ACCURACY



the universal

PYRO SURFACE PYROMETER

Gives precise surface, sub-surface temperatures instantly. Light-weight, rugged. Standard single and double ranges from 0-300°F to 0-1500°F. Also sub-zero and special ranges.

Send for FREE catalog No. 168.

PYROMETER INSTRUMENT CO., INC.
BERGENFIELD 4, NEW JERSEY

CIRCLE 143 ON READER-SERVICE CARD

The ASTRAGAUGE

Safe, Accurate, Easy Reading

For Pressures to 100,000 p.s.i.g.

New 6" diameter gauge is available in 12 ranges from 1,000-100,000 p.s.i.g. Features: multiple turn 316 stainless steel Bourdon element for longer life and greater accuracy; dial readings spread over 300°; expendable diaphragm-type back to relieve internal pressure; safety plate in front of element; no welding or soldering used on element or socket.

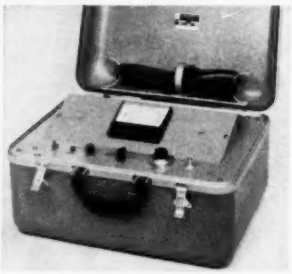
Write for complete data and prices.

ASTRA CORPORATION
HATBORO, PA., OSborne 5-1652

CIRCLE 144 ON READER-SERVICE CARD

RADIATION SURVEY METER

New portable Survey Meter, Model 15-2, an ultra-sensitive transistorized scintillometer, is a self contained,

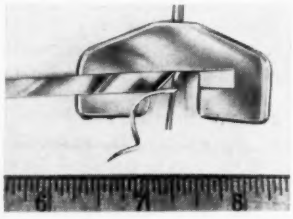


beta-gamma ray responsive instrument for rapid low-level background monitoring, field survey from moving vehicle, or rapid location of contaminated or tagged material. Specification Sheet 1075 gives details.—*Franklin Systems, Inc., 2734 Hillsboro Rd., West Palm Beach, Fla.*

CIRCLE 302 ON READER-SERVICE CARD

THERMOCOUPLE WIRE SKINNER

New small, lightweight Skinner removes sheath metal from thermocouple wire in a manner similar to, and as simple as, the action of a pencil

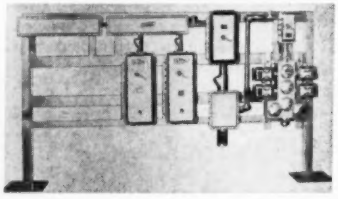


sharpener. The open construction of the skinner provides two important advantages: (1) the exact amount of metal sheath being skinned is always visible, and (2) the cut pieces of sheathing fall out and away from the cutting area and therefore cannot clog or jam the tool. Three sizes are available to accommodate 1/25", 1/16" and 1/8" OD wire.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

CIRCLE 303 ON READER-SERVICE CARD

ALUMINUM SWITCH RACKS

New custom-made aluminum Switch Racks complete with panel boards,



circuit breakers, motor starters, and disconnect switches are made fully wired at the factory.—*Killark Electric Mfg. Co., 3940 Easton Ave., St. Louis 13, Mo.*

CIRCLE 304 ON READER-SERVICE CARD

TIFFEN

LAMINATED & SOLID GLASS **FILTERS**
INDUSTRIAL • SCIENTIFIC • PHOTOGRAPHIC

PRECISION OPTICS
WINDOWS • PRISMS • WEDGES

SPECIALIZED GLASS
VYCOR • PYREX • QUARTZ

PRECISION HOLE DRILLING
TOLERANCES TO .0001"

PRECISION EDGING SAWING, MACHINING
ON ALL TYPES OF GLASS & CERAMICS

PRECISION OPTICAL MACHINING
METAL LENS MOUNTS • BARRELS • EYEPIECES

AUTOMATIC SCREW MACHINES TO 4" DIA. — ALSO HAND SCREW MACHINES — ENGLISH & METRIC THREADS OUR SPECIALTY.

Write for Filter Transmission Curve Catalog.

Tiffen QUALITY PRODUCTS
TIFFEN OPTICAL CO.
INDUSTRIAL DIVISION
71 Jane St., Roslyn Heights, L.I., N.Y.

CIRCLE 145 ON READER-SERVICE CARD

SOLID STATE COMPUTER

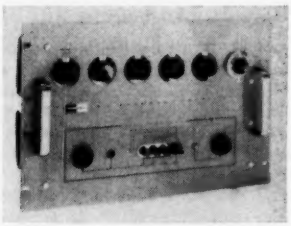
New desk-size Model 160, all-transistorized Electronic Computer has an array of building blocks and a magnetic core memory. It can execute 60,000 instructions/sec and handle up to 65,000 characters/sec to and from in-

put-output equipment. A single-address computer with high-speed parallel mode of operation, it uses five-megacycle logic.—*Control Data Corp., 501 Park Ave., Minneapolis 15, Minn.*

CIRCLE 305 ON READER-SERVICE CARD

AC VOLTAGE STANDARD

New Model 601A Voltage Standard with output voltage from 1 to 501 vac rms, adjustable in tenth-volt steps and between tenth-volt steps by a multi-turn potentiometer, has power output capability of 5 amp up to 5 v and 25 w above 5 v. Frequencies selectable by front panel control are 60,400, and 1000 cps. Voltage accuracy is 0.15 or ±5 mv, whichever is greater. Short term voltage stability



is 0.01%. Frequency stability is 1.0%, and harmonic distortion is less than 0.3%.—*Kin Tel, a div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., Box 623, San Diego 12, Calif.*

CIRCLE 306 ON READER-SERVICE CARD

SCINTILLATION COUNTER

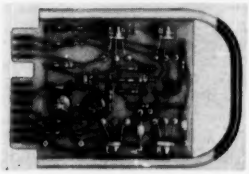
New well-type Scintillation Counter, Model WSC-1, has low background count of 125 counts/min under average conditions, which makes possible more

precise detection of low-level gamma activity in test tube or flat type samples. Works with any scaler or other registering unit. High sensitivity permits detection of 10^{-5} μcuries of I-131 with a counting efficiency of about 50%.—*Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.*

CIRCLE 307 ON READER-SERVICE CARD

TRANSISTOR DIGITAL MODULE

New Schmitt Trigger, Model ST-102, a new transistorized module designed for driving line of M-Pac cir-



cuits, contains 2 independent circuits. Output signal switches between +0.7 and +20 v as the input signal crosses the triggering level.—*Computer Control Co., Inc., 938 Concord St., Framingham, Mass.*

CIRCLE 308 ON READER-SERVICE CARD

The new 20 watt DIEHL† Instrument Servomotor a study in practical design

A carefully constructed winding—set in a round, die cast aluminum housing and totally encapsulated with a protective epoxy resin . . . a low inertia ingot-iron rotor . . . and two sets of prelubricated ball bearings . . . a simple anatomy. Yet these few simple parts combine to make the new 20 watt DIEHL Instrument Servomotor the most practical servomotor ever designed for commercial applications . . . because all costly construction features and environmental precautions which are unwarranted in a commercial application have been eliminated. But full performance and all essential environmental precautions have been retained . . . including moisture, salt, and fungus proofing, good resistance to shock, safe operation in ambients of −55 to +55°C, and these other outstanding performance characteristics:

SPECIFICATIONS AT STALL

Cat. No.	FPE49L-116-1
Output	20 Watts
Voltage (per phase)	115 Volts
Frequency	60 Cycles
Torque	25 oz. in.
Input power (per phase)	54 watts
Control phase impedance	174 ohms
No Load Speed	3500 R.P.M.
Inertia (Wk2)	.725 oz. in.^{2}
Theor. acceleration	13,300 rad/sec.^{2}
Weight	2.75 lbs.
Motor Transfer Function	3.2 / S (.028S + 1
Frequency response	5.75 cyc./sec

Write for more information on our complete line of instrument servomotors. Available in sizes 11 and 15, power ratings from 1 to 20 watts.

Diehl†

DIEHL MANUFACTURING COMPANY

A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY

Somerville, New Jersey

SINGER*

†A Trademark of THE DIEHL MANUFACTURING COMPANY *A Trademark of THE SINGER MANUFACTURING COMPANY

CIRCLE 146 ON READER-SERVICE CARD

New

CS-17 FORCE CALIBRATOR

with Digital Readout

High Accuracy

C and S Force Calibrators are designed for on-the-spot field calibration of testing machines, thrust stands, electronic, hydraulic, or lever weighing systems. They can also be used for general purpose weighing operations. Available with one to four C and S Precision Load Cells. Capacities: 500 to 200,000 lb.

Here are some of the features:

Direct Reading – over entire range . . . no range switch or "Add to Reading" required . . . eliminates human error.

High Resolution – 5000 full digits . . . illuminated dial.

High Accuracy – to 1/20 of 1% of applied load.

Simple Operation – self-balancing servo system . . . minimum panel controls.

Lock-type Zero Adjustment – prevents accidental zero shift.

Complete System – available with one to four C and S Precision Load Cells for individual or totalized reading or both.

Send for Bulletin CS-17 now! 62

CALL ON REVERE . . .
WHEN YOUR PROJECT RATES THE BEST
RATHER THAN "OFF-THE-SHELF" TREATMENT

when you want engineering abilities and specialized facilities in the fields of:

- Liquid Level Indication and Control
- Flow Indication and Control
- Flow Measurement
- High Temperature Wire and Cable
- Thermocouple Wire and Cable
- Thermocouples, Harnesses and Leads
- Electrical and Molded Harnesses
- Weight, Force and Thrust Measurement
- Determination of Center of Gravity
- Strain Gage Load Cells

neptune

REVERE CORPORATION OF AMERICA / *Wallingford, Conn.*
One of Neptune Meter Company's Electronic subsidiaries

CIRCLE 147 ON READER-SERVICE CARD

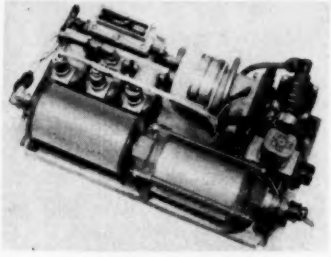
PUSH-BUTTON GENERATOR

New Push-button Generator, used to start, trigger or gate a logic unit or system, consists of a miniature mercury switch and two differentiating output circuits. Two pulses at separate outputs are provided: output one occurs when the switch is depressed; output two when the switch is released.—*Harvey-Wells Electronics, Inc., East Natick Industrial Park, East Natick, Mass.*

CIRCLE 309 ON READER-SERVICE CARD

VOLTAGE-TO-FREQUENCY CONVERTER

New Model 240A Converter includes fully transistorized circuitry which develops a frequency precisely proportional to input voltage with 0.1%

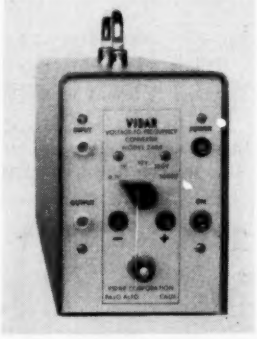


long-term accuracy. Frequency range is 0-100 kc. Full-scale sensitivity can be switched from 0.1 v through 1000 v in five steps. Three package designs are available: rackmount requiring only 3½" of standard 19" rack panel; module suitable for multichannel installations; and cabinet.—*Vidar Corp., 2107 El Camino Real, Palo Alto, Calif.*

CIRCLE 310 ON READER-SERVICE CARD

DEHYDRATOR UNIT

New combination Pressurization and Dehydrator Unit features automatic self-reactivation eliminating



desiccant replacement. Meets MIL E-5400 and MIL M-7969A specs, and can be used on a variety of specific airborne, shipboard, undersea, and ground support equipment.—*Great Lakes Mfg. Corp., 4223 Monticello Blvd., Cleveland 21, Ohio.*

CIRCLE 311 ON READER-SERVICE CARD

RADIATION PYROMETER

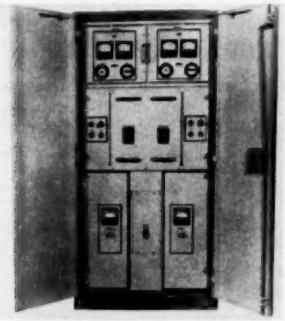
New non-contacting Radiation Monitor, Pyrotel Model PY30; and Controller, Model PY40, for low temperature range of 500-1200°F, can detect small or moving targets from infra-

red radiation emitted between 12" and many feet away with repeat accuracies of ½ of 1% of scale, responding in msec. It can acuate a power relay, signal or control other machine equipment, and is ideal for automating production heating processes. Leaflets give details.—*Mason Instrument Co., Box* 1681, *New York* 1, *N. Y.*

CIRCLE 312 ON READER-SERVICE CARD

PACKAGED CONTROL SYSTEMS

New line of Control System Components includes switchgear, regulators, manual controls, alarms, protective devices, meters, etc. for any con-

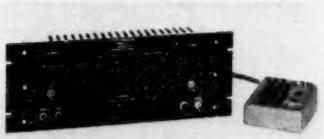


ventional industrial electrical power system. Seven basic standard combinations are provided for the most popular motor-generator and motor-alternator sets, and a total of 27 options are provided in each class.—*Regulators, Inc.*, 455 *W. Main St., Wyckoff, N. J.*

CIRCLE 313 ON READER-SERVICE CARD

DIGITAL TRANSLATOR

New Digital Translator, Model 42, which permits automatic operation of Moseley Autograf or similar X-Y



recorders, is compatible with IBM summary punches and card readers. Accuracy of the digital-to-analog conversion is 0.1%.—*F. L. Moseley Co.*, 409 *N. Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 314 ON READER-SERVICE CARD

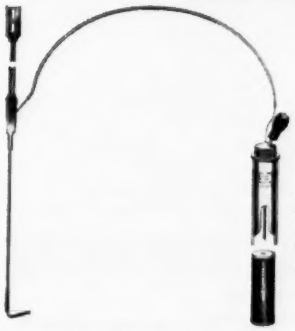
Model 1245
with 1 Osc'r
$930
Q MEASUREMENTS? . . .
1 Kc to 300 Mc? . . .
New Q Meter Model 1245 has widest frequency range ever, is direct reading in Q and Δ Q, and losses are so low that corrections are seldom required. Separate plug in oscillators add flexibility and economy. Does this one instrument cover all your Q measuring requirements?
Freq. Range 1Kc to 300Mc
Q Range 5 to 1000
Δ Q Range to ± 50
Cap. Range 7.5 to 500μμF
Oscillator 1246 40Kc to 50 Mc
Oscillator 1247 20 to 300Mc
Technical Brochure Freely Available

MARCONI INSTRUMENTS

111 CEDAR LANE • ENGLEWOOD, NEW JERSEY

CIRCLE 148 ON READER-SERVICE CARD

NEW! Meter Recorder Marking System with a Slip-In Cartridge!



Esterbrook's *customized* marking systems guarantee you complete satisfaction . . . for *any* type recorder . . . Circular . . . Strip . . . Miniature *or* Plotter!

Customized for your meter recorder by Esterbrook

Give your customers the benefit of *ink cartridge convenience*, and a century of experience in the recording product you build. . . . Now—Esterbrook's Technical Products and Instrument Division will custom-design and build a new marking system for *your* product.

The result: no more breaking down . . . no more hand fixing! With Esterbrook's new *customized* meter recorder you'll conserve operating time . . . *and* you'll receive the free design time and engineering assistance of experts!

For further information write to:
Technical Products & Instrument Division
The Esterbrook Pen Co. • Camden 1, N. J.

TECHNICAL PRODUCTS AND INSTRUMENT DIVISION

The Esterbrook Pen Company

CAMDEN 1, NEW JERSEY

CIRCLE 149 ON READER-SERVICE CARD

Established 1847

QUALITY . . OVER 100 YEARS . . PROGRESS

Glass . . . ALL TYPES

PRECISION EXECUTION for instrument dials and other industrial and technical uses.

CLEAR — X-RAY LEAD PLATE GLASS
COLORED — MALTESE NON-REFLECTING GLASS
SAFETY — MALTESE SATIN GROUND GLASS
TEMPERED — INSTRUMENT LENSES
HEAT RESISTING — PILOT LIGHT LENSES

Mirrors . . .

"EVABRITE" FIRST SURFACE MIRRORS — High reflecting hard metal coatings—direct reflection without parallax.

"EVALAST" Mirrors—silver backing protected by electroplating of copper—Eliminates deterioration through moisture, etc. Conforms to Government specifications.

We solicit your glass and mirror specifications for quotation

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636-638 GREENWICH ST. NEW YORK 14, N. Y.
For New York—WAtkins 4-2121 For New Jersey—MArket 4-5328

CIRCLE 150 ON READER-SERVICE CARD

TANK-O-METER
FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

ANY LIQUID

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

CIRCLE 151 ON READER-SERVICE CARD

INSTRULAB'S NEW

evenvolt
Constant Voltage Unit

REPLACES BATTERIES IN POTENTIOMETERS
- CONTROLLERS
- INDICATORS
- RECORDERS

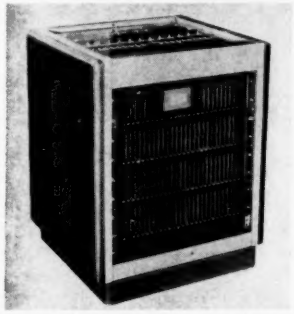
Mfg. By INSTRULAB, INC.
1205 Lamar Street
Dayton 4, Ohio
Phone BA 3-2241

Outstanding FEATURES
- Eliminates batteries ...errors due to battery exhaustion
- Reliable construction...from quality components, long, trouble-free service
- A Precise voltage regulator . . . max. ±.04% for ±20% voltage variation
- Quickly Installed... Fits present instrument battery space.
- No Tubes to replace

CIRCLE 152 ON READER-SERVICE CARD

MAGNETIC MEMORIES

New Series 3100 Magnetic Memories, high-speed coincident-current, random access storage units with a range of storage capacities from 128 to 4096 words and from 4 to 64 bits per word, accept digital information

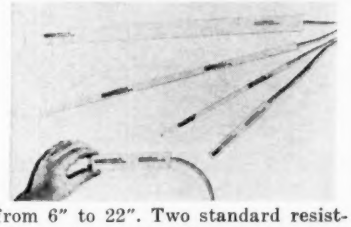


either synchronously or asynchronously, store the information in randomly specified or sequential addresses, and can be supplied with binary or binary-coded decimal address. Apertured ferrite plate memory stacks or core stack plug-ins are used as the memory storage medium, and all circuits are on etched, glass-epoxy plug-in boards.—*Rese Engineering, Inc.*, 731 *Arch St., Phila.* 6, *Pa.*

CIRCLE 315 ON READER-SERVICE CARD

TEMPERATURE SENSORS

New Class H Resistance Temperature Detectors for applications to 260°C (500°F) are made in any width from 0.30" to 1.25" and in any length

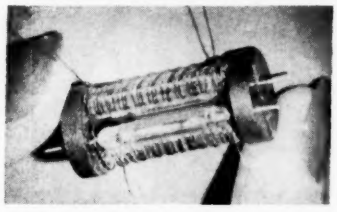


from 6" to 22". Two standard resistance values available are 10 ohms ±0.02 ohms at 25°C with temperature coefficient of 0.00385 ohms/ohm/°C at 25°C, and 120 ohms ±0.6 ohms at 0°C with temperature coefficient of 0.00672 ohms/ohm/°C.—*Minco Products, Inc.*, 740 *Washington Ave., North, Minneapolis* 1, *Minn.*

CIRCLE 316 ON READER-SERVICE CARD

MICROSECOND MEMORY

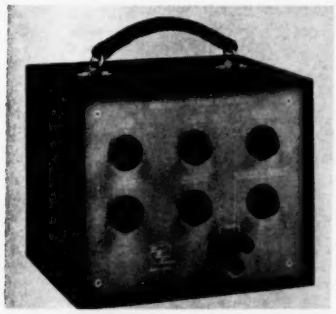
New very fast Electromechanical Switch called, the "ferreed," has metallic contacts controllable by current



pulses of a few μsec duration. It combines the rapid switching of bistable magnetic material with metallic contacts for output indications that persist as long as desired without further application of power. In several models of the device, a cobalt ferrite has been used. Several new magnetic materials have been synthesized for use in development models of the ferreed.—*Bell Telephone Labs., 463 West St., New York 14, N. Y.*

VOLTAGE REFERENCE SOURCE

New all-solid-state Precision Voltage Reference Source for calibration of telemetry, data reduction and lab-

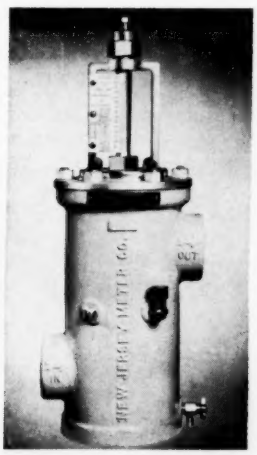


oratory equipment is available either portable or rack mounted. Basic unit is a 4-decade direct-reading device with full scale of ±11.111 v in 1.0-mv. steps.—*Electronic Development Corp., 423 West Broadway, Boston 27, Mass.*

CIRCLE 317 ON READER-SERVICE CARD

AIR METER

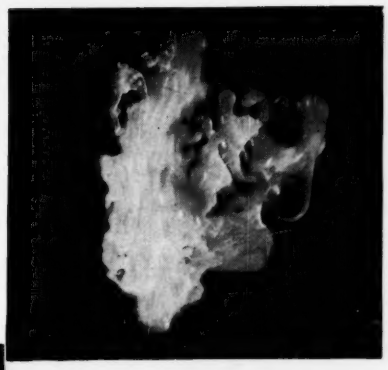
New wide-range Air Meter, Model DO-150, for air flows in 2" pipe lines from 10 to 150 cfm in 2 cfm increments, features cast-iron and brass

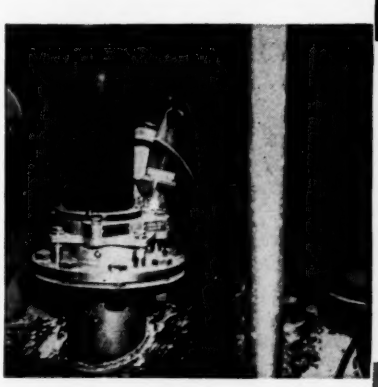


construction, operation pressure of 80 psig and (with conversion factors) volumetric readings at pressures ranging from 2 to 300 psig. Accuracy is ±1%.—*New Jersey Meter Co., Inc., 350 Leland Ave., Plainfield, N. J.*

CIRCLE 318 ON READER-SERVICE CARD

YES, NOW VISCOSITY



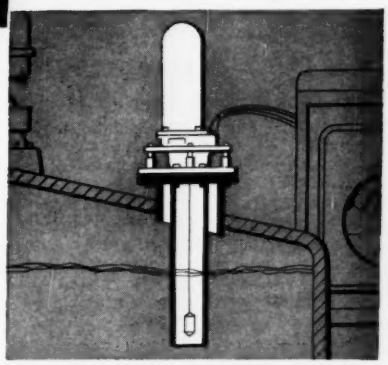


CAN BE CONTINUOUSLY

PROCESS CONTROLLED

WITH THE

BROOKFIELD VISCOMETRAN



UNDER actual process conditions, the Brookfield Viscometran accurately and continuously measures, records and controls viscosity. Readily mounted and integrated in existing processes, the Viscometran offers significant economic advantages over other methods of indicating degree of reaction, degree of polymerization or determination of process end point.

Viscosity is very likely a variable that is fundamental in your process. For complete information about how the Brookfield Viscometran can provide continuous "in process" measurement of this product dimension for you, write—

THE WORLD'S STANDARD FOR VISCOSITY MEASUREMENT AND CONTROL

Brookfield

ENGINEERING LABORATORIES, INCORPORATED

STOUGHTON 316, MASSACHUSETTS

BROOKFIELD VISCOMETRANS NOW SUCCESSFULLY USED FOR CONTROLLING:

Asphalt • Caramel • Cement slurries • Durezresin-acetone slurries • Gluten slurries • Lignum-based polymers • Molten P_2S_5 • Paper coatings • Polystyrene • Polyurethane resins • Ureaformaldehyde resin

CIRCLE 153 ON READER-SERVICE CARD

18 million... 396 thousand gallons...

Waugh FF SERIES
fluid bearing
FLOW SENSOR

THE NEW STANDARD OF THE INDUSTRY

This **Waugh FF Series FLUID BEARING** flow sensor has been operating at close to maximum output **continuously** for a full year... and is still operating well within original accuracy tolerances. **18,396,000 gallons of water** have passed through it!

The **proven** service life of the **FF Series** sensor introduces a new standard of operation and a new degree of accuracy and reliability for precision measurement of cryogenics, jet-aircraft fuels, and many other difficult to handle fluids.

Available in a wide range of flow rates, it is the **only** sensor with no mechanical contact between the rotor and stationary elements. The turbine is supported by a filtered film of the fluid being measured adding to linearity and eliminating wear from either radial or thrust friction. The absence of conventional bearing surfaces results in reproducibility within 0.1% of flow rate, with linearity held to ±½%.

The outgrowth of many years experience in the design and production of flow instrumentation, the **FF Series** has almost universal application, and sets a new standard for the industry.

Request Bulletin 109 for complete technical data.

Waugh Engineering Representatives in Principal Cities

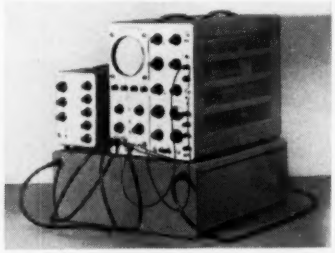
WAUGH ENGINEERING COMPANY
7842 Burnet Avenue, Van Nuys, Calif.
STate 2-1710

CIRCLE 158 ON READER-SERVICE CARD

NEW INSTRUMENTS

PULSE SAMPLING SYSTEM

New Pulse Sampling System allows faster observation of recurrent signals than afforded by the normal capabilities of Type 530, 540, and 550-Series oscilloscopes. Risetimes to approx. 0.6 nsec (nanosec) can be investigated with the system. Displays

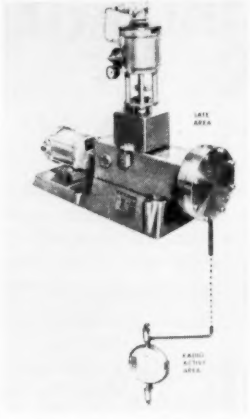


with apparent sweep times of as little as one nsec can be provided (with magnifier, 100 picosec/cm). The Pulse sampling system, in addition to the oscilloscope, consists of a Type N Sampling Plug-in Unit, a Type 110 Pulse Generator and Trigger Takeoff, and a Type 113 Delay Line.—*Tektronix, Inc., Box* 831, *Portland* 7, *Ore.*

CIRCLE 322 ON READER-SERVICE CARD

RADIOACTIVE FLUIDS PUMPS

New Remote Head Pulsafeeder positive-displacement Pumping Unit,

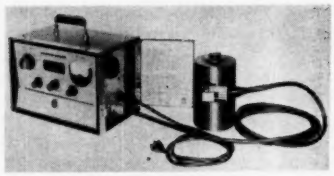


Model CPS-4-AP, safely handles high-level raidoactive fluids by its welded-diaphragm reagent head that can be placed in intensely radioactive areas at a remote distance from the pumping unit.—*Lapp Insulator Co., Equipment Div., LeRoy, N. Y.*

CIRCLE 323 ON READER-SERVICE CARD

PORTABLE CALIBRATION KIT

New portable Calibration Kit provides a convenient unit for checking and calibrating tension- and/or compression-load output in weighing sys-

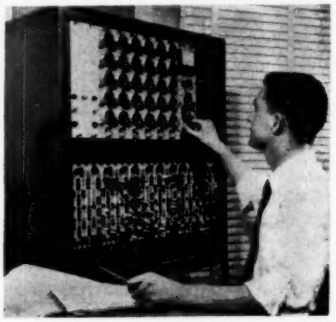


tems, jet engine test stands, missle thrust stands and similar applications. Kit contains a precision calibration indicator featuring digital readout and a high-accuracy calibration load cell. Combined, these units guarantee direct-reading accuracies of as high as 1/20% of reading.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div.,* 42 *Fourth Ave., Waltham* 54, *Mass.*

CIRCLE 324 ON READER-SERVICE CARD

DESKTOP COMPUTER

New low-cost analog computer, the AD-1 Electronic Differential Analyzer, for desktop use, is about the

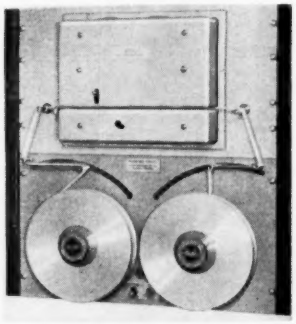


size of a TV set and priced to sell at $2,000. As a modular system, more complex components can be added to the computer, as required.—*Bowmar Instrument Corp.,* 8000 *Bluffton Rd., Ft. Wayne, Ind.*

CIRCLE 325 ON READER-SERVICE CARD

PUNCHED TAPE READER

New punched tape-reader (Model 909) and spooler-mechanism (Model 3299) combination includes a com-

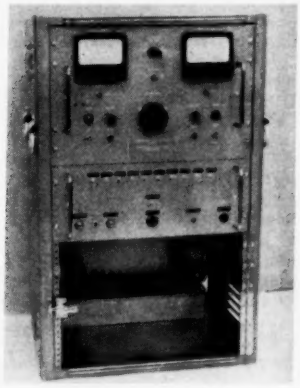


pletely transistorized electronic readout system with output signals compatible with most data processing systems.—*Potter Instrument Co., Inc., Plainview, N. Y.*

CIRCLE 326 ON READER-SERVICE CARD

SEMI-AUTOMATIC TEST SET

New semi-automatic test set features integral construction for nondestructive hipot testing of a group



of components or multi-conductor cable. Cabinet houses a 0-10-kv ac/dc sensitive hipot tester, a central panel for control of testing sequence, and a heavy lucite interlocked door leading to a large compartment for the group of components to be tested.—*Peschel Electronics, Inc., R. F. D. #1, Patterson, N. Y.*

CIRCLE 327 ON READER-SERVICE CARD

RECORDER-RECEIVERS

New Chronoflo Recorder-Receiver arrangements include newly-engineered power positioner with 2-, 4-,

8-, 15-, and 60-sec time-cycles, up to 16 control switches for alarm and control functions, swing-out panel for easy access, modular construction, and multiple pen arrangements,—*B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.*

CIRCLE 328 ON READER-SERVICE CARD

FLOW CONTROL VALVE

New Micrometer Flow Control Valve, Model F4, features linear tenfold flow rate increase through 15 turns. As flow adjustment is based on length of flow passage, the flow passage area is constant. This design feature serves to greatly reduce possibility of clogging, particularly at low-flow settings.—*Sanders Associates, Inc., 95 Canal St., Nashua, N. H.*

CIRCLE 329 ON READER-SERVICE CARD

a NEW approach to flow control

"FLOW TESTED"

Uniflow

BAR STOCK AIR OPERATED

CONTROL VALVES

In sizes ¼" to 1" with body ratings to 15,000 psi in steel, 15,000 psi in stainless and 800 psi in brass. Straight-through or Angle Type valve bodies, 3-15 psi, Air to open—Air to close.

- Flow Co-efficient: Cv. .00001 to Cv. 3.0 with Linear Plug and removable seat are standard construction.
- Parabolic & equal % plugs Cv 0.55 to Cv 6.0
- Complete design features to meet your specifications.
- For special applications—body and trim material can be furnished in Monel, Aluminum, and Hastelloy "C"
- Optional features available: Bellows Seal, Cooling Fins, Top Mounted Moore Valve Positioners. Weld end Bodies and Side Mounted Foxboro Positioners.

Uniflow Valve Corporation

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CIRCLE 157 ON READER-SERVICE CARD

LAMP ANNUNCIATORS

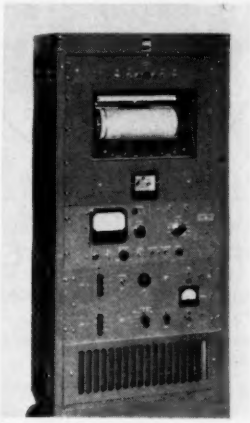
New line of flexible, modular industrial lamp annunciators and annunciator systems features plug-in circuits, multiple lamps to insure against burn-out, "snap-in" indicator plates,

sequential circuits, data-logging terminals, snap-fit one-piece molded lamp compartments, etc. Alarm is visual and aural. Annunciators can start up or shut down any desired machinery; feed information to data-logging or other control equipment; and reset themselves. Power consumption is low, no dropping resistors are used. Steel cabinets are available as flush panel-mounted types with rear access terminals, flush wall-mounted types with front access terminals, and surface-mounted types with front access terminals. Sizes vary from 1" x 3" to 1½" x 2" to 2" x 3".—*Edwards Co., Inc., Norwalk, Conn.*

CIRCLE 330 ON READER-SERVICE CARD

VIBRATION TRANSMISSIBILITY RECORDER

New Continuous Transmissibility Recorder permits continuous transmissibility as a function of frequency



recording with greater speed and accuracy than previous point-by-point manual methods. In addition to vibration testing, it permits use with signal voltages in the frequency range of 10 to 5,000 cps, measuring their frequency, computing their average amplitude values and plotting ratio as a function of frequency.—*Lord Mfg. Co., Erie, Pa.*

CIRCLE 331 ON READER-SERVICE CARD

New...from MARSH!

MARSH *Master-mite* SOLENOID VALVES

Conduit-type Master-mite. Grommet-type also available.

Small Solenoid Valves that fill a BIG Order

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes: 3/64" through 1/4".

Wide range of voltages:
Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A. C.

Pressure to 540 psi.
Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

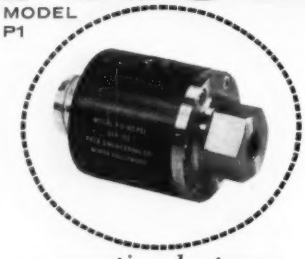
Write for new bulletin

MARSH INSTRUMENT COMPANY
Dept. 42, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

CIRCLE 154 ON READER-SERVICE CARD

PACE

MODEL P1



magnetic reluctance
PRESSURE TRANSDUCER

Ranges: 0.1 to 1,000 psi — Gage, Differential and Absolute.

Pressure Media: Corrosive liquids or gases, both sides.

Withstands Extreme Pressure Overload.

Insensitive to Shock and Vibration — Not oil filled.

PACE's Model P1 is designed for low and medium pressure applications of laboratory accuracy.

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CIRCLE 155 ON READER-SERVICE CARD

Instrumentation
for
Flow
Visualization

Schlieren Systems
Interferometers
Wind Tunnel Optics

Our new catalog is now available

John Unertl Optical Co.
3551-3555 East Street
Pittsburgh 14, Penna.

CIRCLE 156 ON READER-SERVICE CARD

ICS NEW LITERATURE

MOTORS CONTROLLERS

MAGNETIC STARTERS. 8-page Bulletin PL 12-8-160 gives engineering data on controllers-type 'CY' a-c starters.—Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.

CIRCLE 332 ON READER-SERVICE CARD

FHP MOTORS. 4-page catalog contains illustrations and technical data on fractional and sfhp electric motors. —Speedway Mfg. Div., Thor Power Tool Co., 1421 Barnsdale Rd., La-Grange Park, Ill.

CIRCLE 333 ON READER-SERVICE CARD

MOTOR CONTROLS. 6-page folder, titled "½ the Size of Conventional Controls," defines the principle of the Type "RA" design starters and contractors.—Arrow Hart & Hegeman Electric Co., Hartford, Conn.

CIRCLE 334 ON READER-SERVICE CARD

VALVES, ACTUATORS

CONTROL VALVES. 20-page Form 608.342 describes and specifies automatic split-body control valves.—Hammel-Dahl Div., General Controls Co., Warwick Industrial Park, Warwick, R. I.

CIRCLE 335 ON READER-SERVICE CARD

MOTOR ACTUATORS. 24-page Catalog 407 describes line of electric motor operators and motorized valves.—Schade Valve Mfg., Co., 2527 N. Bodine St., Phila. 33, Pa.

CIRCLE 336 ON READER-SERVICE CARD

BUTTERFLY VALVES. 4-page Bulletin 590X illustrates and describes advantages and features of resilient-seated types hand- and air-operated butterfly valves.—W. S. Rockwell Co., 300 Eliot St., Fairfield, Conn.

CIRCLE 337 ON READER-SERVICE CARD

SLIDING GATE CONTROL VALVES. 8-page Bulletin J-170 contains sectional sketches, applications, capacity tables, etc. of process control valves. —OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 338 ON READER-SERVICE CARD

TEMPERATURE

THERMOCOUPLE COMPONENTS. 4-page Specification Sheet FS005-3 describes new line of QuiK-Konnect thermocouple components.—Minneapolis-Honeywell Regulator Co., Penn and Bay St., Fall River, Mass.

CIRCLE 339 ON READER-SERVICE CARD

HI-TEMP SWAGEABLE T/C TUBING. 2-page reference sheet illustrates ceramic thermocouple tubing and tabulates sizes, chemical analysis, and tolerances.—Saxonburg Ceramics, Inc., Saxonburg, Pa.

CIRCLE 340 ON READER-SERVICE CARD

ADJUSTABLE-ANGLE THERMOMETERS. New 8-page Catalog #400 describes and illustrates maker's adjustable-angle industrial thermometers designed to eliminate parallax error and provide ease of reading.—Moeller Instrument Co., Inc., 132nd St. and 89th Ave., Richmond Hill 18, N. Y.

CIRCLE 362 ON READER-SERVICE CARD

THERMISTORS. 6-page folder from E14 describes type "K" and "D" thermistors and 2 leaflets describe kit containing 12 samples.—Walter Kidde & Co., Inc., Main St., Belleville, N. J.

CIRCLE 341 ON READER-SERVICE CARD

PIEZOELECTRICITY. 6-page booklet describes "Elements of Piezoelectricity."—U. S. Sonics Corp., 625 McGrath Highway, Somerville, Mass.

CIRCLE 342 ON READER-SERVICE CARD

FLOW

LINEAR FLOW TRANSMITTERS. 4-page Product Specification P22-1 describes force-balance pneumatic transmitters which extract the square root function, producing a signal varying linearly with rate of flow.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 343 ON READER-SERVICE CARD

D/P TRANSMITTERS. 6-page Bulletin discusses adjustable damping advantages in d/p transmitters.—Fischer & Porter Co., 475 Jacksonville Rd., Warminster, Penna.

CIRCLE 344 ON READER-SERVICE CARD

PRESSURE, WEIGHT, ACCELERATION

VERTICAL INDICATING GAGES. 12-page Bulletin 59-1 describes miniature vertical-type gages with 5-inch scales for measuring and indicating draft, pressure, differential pressure, temperature, and pneumatic signals.—Republic Flow Meters Co., subsidiary of Rockwell Mfg. Co., 2240 Diversey Parkway, Chicago 47, Ill.

CIRCLE 345 ON READER-SERVICE CARD

PRESSURE GAGES. 4-page Bulletin DH-23-A illustrates various gage cases and describes advantages of exclusive Helicoid movement.—Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.

CIRCLE 346 ON READER-SERVICE CARD

PRESSURE MEASURING ELEMENTS. 16-page catalog, titled "Pressure Measuring Elements," covers diaphragm and Bourdon tube elements.—U. S. Gauge Div., of American Machine and Metals, Inc., Sellersville, Penna.

CIRCLE 347 ON READER-SERVICE CARD

DIAPHRAGM SEALS. 24-page Bulletin 250 contains description, specs and prices of seals for protection of pressure instruments against corrosion and clogging.—Brooks Rotameter Co., Box 432, Lansdale, Penna.

CIRCLE 348 ON READER-SERVICE CARD

LIQUID SPRING SHOKS. 12-page Handbook CH illustrates and describes liquid spring shoks.—Taylor Devices, Inc., North Tonawanda, N. Y.

CIRCLE 349 ON READER-SERVICE CARD

D-C AMPLIFIER EVALUATION *number 1 in a series*

AMPLIFIER NOISE

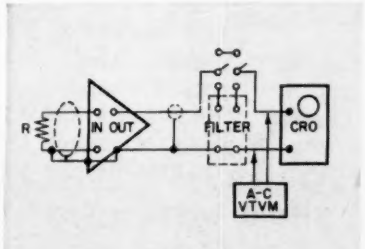
Accuracy is the basic objective in amplifier selection. When evaluating amplifiers for specific applications all errors must be considered. One such error, the noise level, determines the ultimate accuracy of the amplifier since the smallest observable signal cannot be less than the noise level. However, noise outside the frequency response range of the amplifier load can be filtered out or ignored with such read-out devices as galvanometer oscillographs.

Noise in an amplifier is any voltage component appearing at the output that has no counterpart in the input signal. Usually only the a-c component of the output is termed noise. The d-c component is called zero drift and its evaluation will be covered in another of this series.

Internally generated a-c components must be evaluated as to amplitude and frequency range. Noise may be divided into two general classes and measured as described below. (a) *Random voltages* of a broad band nature arising from thermal agitation in resistors and random tube or transistor noise . . . measurements on a peak-to-peak basis are often 10 times or more larger than the measured rms value over the same frequency band. (b) *Narrow band voltages* induced within the amplifier by line voltage or chopper excitation . . . these voltages are generally sinusoidal so that peak-to-peak values are only about 2.8 times larger than the measured rms values.

Testing amplifiers for noise

If the input signal is zero, any voltage components detected at the



amplifier output can be identified as noise. A standard technique for measuring noise is shown.

The oscilloscope measures the peak-to-peak values, the VTVM in rms values. Equivalent input noise (eq. in) is the measured noise divided by the amplifier gain. For details write for Bulletin BE AN121.

Noise less than 0.03%

With a full scale input range of 30 mv, Honeywell's AccuData II Amplifier has a wide band (0-100 KC) noise specification of 8 μv (eq. in) and a peak-to-peak noise over a 0-10 cps band of 8 μv (eq. in) . . . less than 0.03% of full scale!

The AccuData II, a wide band differential input d-c amplifier with all transistor design, is especially useful for driving analog-to-digital converters, f-m magnetic tape systems and high speed oscillographs where low level signals such as thermocouple, strain gage and similar transducer outputs are to be accurately measured. Write for Bulletin BS DISA-1000 to Minneapolis-Honeywell, Boston Division, Dept. 50, 40 Life Street, Boston 35, Mass.

Honeywell

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SINCE 1885

CIRCLE 159 ON READER-SERVICE CARD

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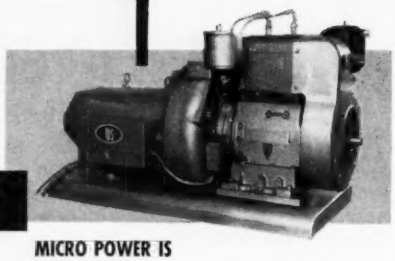
TULSA DIVISION . . .
assures effectiveness of its protective boiler flame controls with . . .

MICRO POWER



In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, this is achieved with MICRO POWER.

At Douglas Aircraft in Tulsa, Micro Power serves as the dependable rear guard to the boiler room. It provides a constant source of steady, independent electrical power as required by the safety controls, thereby eliminating voltage fluctuations and protecting against power failure.

MICRO POWER IS ALSO USED . . .

- on microwave systems for communications, for remote control, for telemetering.
- for refinery and chemical process indication and control.
- by public utilities through microwave for protective relaying, telemetering and load distribution.

MICRO POWER PROVIDES . . .

- a constant uninterrupted source of electric power.
- voltage and frequency at usable value during transfers between motor and engine.
- stable voltage output.
- flywheel starting — no storage batteries.
- electrical isolation from commercial source — voltage dips, peaks and breaks do not affect microwave equipment, no transfer switch.

For complete information on this and other Micro Power applications, write . . .

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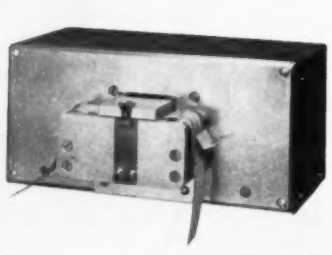

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CAPACITY:	Up to 30 lines per reading (240 bits.)
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JAMAICA 35, N. Y.

CIRCLE 162 ON READER-SERVICE CARD

VIBRATION METER. 2-page brochure describes Model T-1A vibration meter. —Southwestern Industrial Electronics Co., div. of Dresser Industries, Inc., 10201 Westheimer, Box 22187, Houston 27, Tex.

CIRCLE 350 ON READER-SERVICE CARD

PRE-MIX WEIGHING SYSTEM. 2-page Data Sheet 5903, describes the controls of the pre-mix weigh system. —Richardson Scale Co., Clifton, N. J.

CIRCLE 351 ON READER-SERVICE CARD

DIFF PRESSURE GAGES. 4-page Bulletin 960 describes and specifies d/p gages.—Mid-West Instrument, 1021 E. State Fair, Detroit 3, Mich.

CIRCLE 352 ON READER-SERVICE CARD

DIFF PRESSURE INDICATOR. 2-page Data Sheet 172 describes a new d/p indicator.—Hastings-Raydist, Inc., Hampton, Virginia.

CIRCLE 353 ON READER-SERVICE CARD

AIR

WIND INSTRUMENTS. 12-page Bulletin 6000 features an anemometer, capable of reading wind velocity in three units and a portable wind recording station.— W. & L. E. Gurley, Troy, N. Y.

CIRCLE 354 ON READER-SERVICE CARD

AIR CONDITIONING. 16-page brochure "Dollars Out of the Air" describes conditioning of air.—Surface Combustion, Toledo 1, Ohio.

CIRCLE 355 ON READER-SERVICE CARD

VACUUM PUMP, AIR COMPRESSOR. Two 2-page bulletins describe miniature oil-less vacuum pumps and air compressors.—Gast Mfg. Corp., Benton Harbor, Mich.

CIRCLE 356 ON READER-SERVICE CARD

NUCLEONICS

NUCLEAR INSTRUMENTS. 8-page Short Form Catalog D-100 describes instruments for nuclear research and process control.—Eldorado Electronics, 2821 Tenth St., Berkeley 10, Calif.

CIRCLE 357 ON READER-SERVICE CARD

MEDICAL RADIATION METERS. 8-page Form 3123-9 catalogs the medical radiation measuring instruments such as Condenser r-Meter, Radocon, Roentgen Ratemeter, and Iometer.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 358 ON READER-SERVICE CARD

ACTIVATION ANALYSIS. 6-page issue of "The RCL Counter," Vol. 7/No. 2, contains an article on how to manufacture radioisotopes in laboratory production.—Radiation Counter Labs., Inc., Nucleonic Park, Skokie, Ill.

CIRCLE 359 ON READER-SERVICE CARD

DATA HANDLING

DATA LOGGING SYSTEM. Two-page Data Sheet N-07 describes 100-channel sequential data logging system. —Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 360 ON READER-SERVICE CARD

DIGITAL COMPUTER. 4-page folder describes the completely transistorized digital computer Model 2003.—General Mills, Inc., Mechanical Div., 1620 Central Ave., Minneapolis 13, Minn.

CIRCLE 361 ON READER-SERVICE CARD

MONITORS, RECORDERS

INDUSTRIAL LAMP ANNUNCIATORS 24-page Bulletin A-200 describes a new line of flexible, modular industrial lamp annunciator systems.—Edwards Co., Inc., Norwalk, Conn.

CIRCLE 363 ON READER-SERVICE CARD

RECORDER DRIVE. 4-page Bulletin 1107 describes advantages of Gas Drive unit, a continuously-powered chart drive.—Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

CIRCLE 364 ON READER-SERVICE CARD

TESTING

TEMPERATURE TEST CHAMBER. 2-page leaflet describes ValuMite, low- and high-temperature test chamber.—International Radiant Corp., 577 East 156 St., New York 55, N. Y.

CIRCLE 366 ON READER-SERVICE CARD

RELAY TESTERS. 48-page Bulletin SB-RT-1 describes new line of relay test units.—Multi-Amp Div., Multi-Amp Electronic Corp., 465 Lehigh Ave., Union, N. J.

CIRCLE 367 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

ELECTRICAL INSTRUMENTS. 12-page Bulletin 19-60-27 contains condensed descriptions of resistance testers, cable fault locating equipment, frequency meters, tachometers, etc.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

CIRCLE 368 ON READER-SERVICE CARD

VOLTAGE REFERENCE SOURCE. 6-page brochure describes three new secondary standard precision voltage reference sources.—Epsco, Inc., Equipment Div., 275 Massachusetts Ave., Cambridge, Mass.

CIRCLE 369 ON READER-SERVICE CARD

INDUSTRIAL SOLENOIDS. 12-page Bulletin GEA-6215B discusses complete line of Strongbox solenoids, including a-c and d-c forms.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 370 ON READER-SERVICE CARD

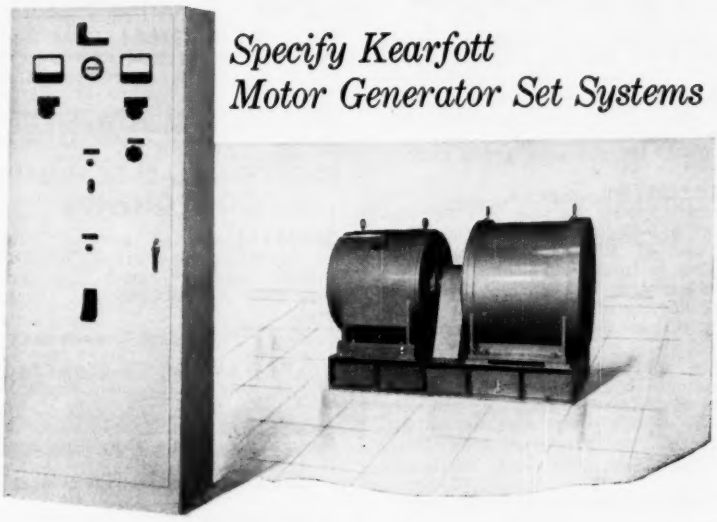
OPERATIONAL AMPLIFIERS. 6-page reprint reviews use of operational amplifiers in precision current regulators, and in accelerator beam control systems, described in papers by Karl Eklund.—George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.

CIRCLE 371 ON READER-SERVICE CARD

PANEL INSTRUMENTS. 24-page Bulletin 3-15 illustrates and describes a-c and d-c meters.—Federal Pacific Electric Co., Fifty Avenue, L., Inc., Newark 1, N. J.

CIRCLE 372 ON READER-SERVICE CARD

FOR PRECISE 400-CYCLE POWER



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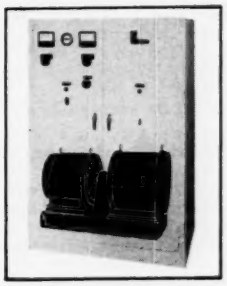
Kearfott 60-to-400 cycle motor generator frequency converters are in active use wherever precise 400-cycle power must be supplied . . . including laboratories and in such other representative applications as production testing, high speed tool operation and ground support. These generator systems, which consist of a 60 cycle synchronous motor and a 400 cycle generator, can be supplied with controls and generator as an integral, compact unit—or with controls and generator separately located.



PERFORMANCE SPECIFICATIONS

Frequency: 400 cycles under any rated load condition with 60 cycle input.

Voltage Regulation: Within ±1% of rated voltage when (1) load varies between no-load and 125% of rated load, and/or (2) load power factor varies between 0.8 lagging and unity, and/or (3) equipment temperature varies after approximately 10 minutes' operation.

Voltage Recovery: When rated load is suddenly applied or removed, voltage will return to and remain within regulating band within 0.25 seconds.

Voltage Adjustment: Continuously adjustable to ±10% of rated value.

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Overload: Equipment delivers 125% of rated load for 2 hours.

Amplitude Modulation: Maximum 1% of peak-to-peak voltage at any load between no load and full load, at any power factor between 0.8 lagging and unity.

Frequency Modulation: Maximum 0.5% at any load from no load to 125% of rated load.

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CIRCLE 163 ON READER-SERVICE CARD

SIGNAL CONDITIONING EQUIPMENT. 6-page Bulletin 109 describes Series 3000 carrier system for conditioning the output of reluctance-type transducers for recording and/or control applications.—Wiancko Engrg. Co., 255 North Halstead Ave., Pasadena, Calif.

CIRCLE 373 ON READER-SERVICE CARD

ELECTRONIC INSTRUMENTS. 2-page short Form Catalog describes power supplies standard bridge, megatrometer, and resistor standards.—Mideastern Electronics, Inc., 32 Commerce St., Springfield, N. J.

CIRCLE 374 ON READER-SERVICE CARD

RECTIFIERS. 8-page "Rectifier News," Spring Edition, RN-360 contains a 5-page article entitled "Properties of Rectifiers Systems and Means to Improve Voltage Division."—International Rectifier Corp., El Segundo, Calif.

CIRCLE 375 ON READER-SERVICE CARD

VAW METERS. 4-page short Form Catalog C-260-1 illustrates and specifies 17 different products, including VAW meters, power supplies, and differential voltmeters.—John Fluke Mfg. Co., Inc., Box 7161, Seattle 33, Wash.

CIRCLE 376 ON READER-SERVICE CARD

BRIDGES, DIVIDERS. 4-page Catalog A-26 describes and illustrates measurements instruments and components.—Electro Scientific Industries, Inc., 7524 S. W. Macadam St., Portland 19, Ore.

CIRCLE 377 ON READER-SERVICE CARD

TRANSFORMERS. 36-page catalog covers transformers and filter reactors.—Chicago Standard Transformer Corp., 3501 W. Addison St., Chicago 18, Ill.

CIRCLE 378 ON READER-SERVICE CARD

MAGNETS

LIFTING MAGNETS. 2-page Bulletin 3021 describes and illustrates new line of Pow-R-Ligth lifting magnets.—Stearns Magnetic Products, 635 South 28th St., Milwaukee 46, Wis.

CIRCLE 379 ON READER-SERVICE CARD

INDOX MAGNETS. 8-page Catalog 18A and 2-page Bulleitn 353 contains information on Indox I & V and Indox VI, respectively.—Indiana Steel Products, Div., Indiana General Corp., Valparaiso, Ind.

CIRCLE 380 ON READER-SERVICE CARD

SWITCHES

SUB-SUBMINIATURE SWITCHES. 2-page Data Sheet 169 describes the new environment-free sub-subminiature switch, catalog listing 1XE1.—Micro Switch, Freeport, Ill.

CIRCLE 381 ON READER-SERVICE CARD

SPECIAL SWITCHES. Three 4-page Bulletins S-301,S-302, and S-303 contain sketches and specifications of button-type, lever-type, and hook-type switches, respectively.—Switch-craft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.

CIRCLE 382 ON READER-SERVICE CARD

RESISTORS

METAL FILM RESISTORS. 6-page Bulletin 04-101-A gives technical data on the Vamistor, a precision metal film resistor.—Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N. J.

CIRCLE 383 ON READER-SERVICE CARD

PRECISION RESISTORS. 2-page Bulletin 153B describes molded wirewound, power, precision resistors.—Ohmite Mfg. Co., 3664 Howard St., Skokie, Ill.

CIRCLE 384 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

CHOPPERS. 8-page general instrument catalog describes miniature chopper models.—James Electronics Inc., 4050 N. Rockwell St., Chicago 18, Ill.

CIRCLE 385 ON READER-SERVICE CARD

MICROWAVE SWEEP OSCILLATOR. 4-page issue of "Technical Bulletin," Vol. 1/No. 1, describes broad-band microwave sweeping oscillator.—Kay Electric Co., Maple Ave., Pine Brook, N. J.

CIRCLE 386 ON READER-SERVICE CARD

MECHANICAL COMPONENTS

INSTRUMENT BEARINGS. 4-page Bulletin 6002 contains dimensional sketches and specs of high-precision thin-width bearings for synchros, gear trains, potentiometers, servos, and small motors.—Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.

CIRCLE 387 ON READER-SERVICE CARD

CAPTIVE NUTS. 2-page Bulletin No. 58-2SL describes new line of self-locking captive nuts.—National Radio Co., Inc., Malden, Mass.

CIRCLE 388 ON READER-SERVICE CARD

MISCELLANEOUS

SCIENTIFIC INSTRUMENTS. 16-page General Catalog 1313 describes instruments for labratory analysis, process control, and research.—Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 389 ON READER-SERVICE CARD

SPEED GOVERNOR. 2-page Bulletin 265 covers application of the Synpro-Tex speed detector for fuel and fuel mixture control on power gas burners. Torq Engineered Products, Inc., 32 W. Monroe St., Bedford, Ohio.

CIRCLE 390 ON READER-SERVICE CARD

RUBBERIZED ABRASIVES. 22-page manual contains information concerning rubberized abrasives and typical applications.—Cratex Mfg. Co., Inc., 1600 Rollins Rd., Burlingame, Calif.

CIRCLE 391 ON READER-SERVICE CARD

ULTRASONIC CLEANING LIQUIDS. 10-page brochure covers line products for integrated ultrasonic cleaning and rust-proofing systems.—Rust-Lick, Inc., Dept, 6, 755 Boylston St., Boston 16, Mass.

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Giant 8" Dial

GRA LAB INTERVAL TIMER Automatic signalling and switching over unusually wide range of 3600 possible setting.

GRA LAB MICRO TIMER 1/10 sec. or 1/1000 min. stop clock. Remote start stop control. Write for catalog.

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THE ROLYN
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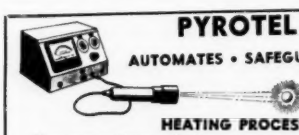

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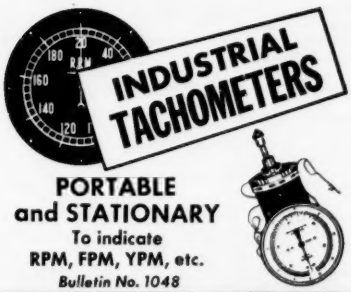

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To indicate
RPM, FPM, YPM, etc.
Bulletin No. 1048

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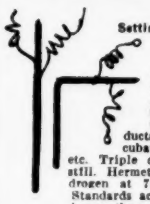

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Set Sensitivity: ±.01°C

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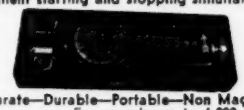
T-110 HAND SPEED INDICATOR
Ingenious combination of counter and watch movement starting and stopping simultaneously



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For speeds up to 6,000 R.P.M. on machines, motors, shaftings, etc.
ADVANTAGES: Operates in either direction. One turn of knob resets counter & stop watch. Light weight —8 oz., Numerical readings

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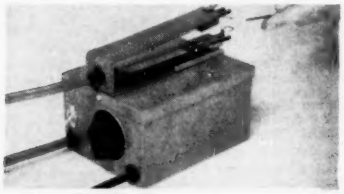

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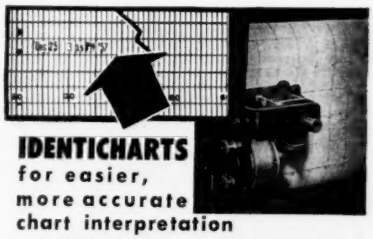

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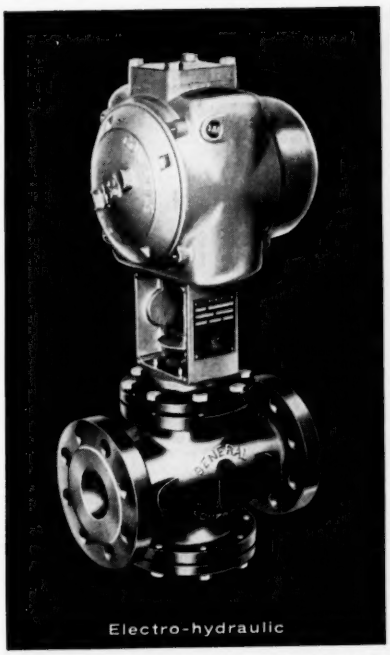

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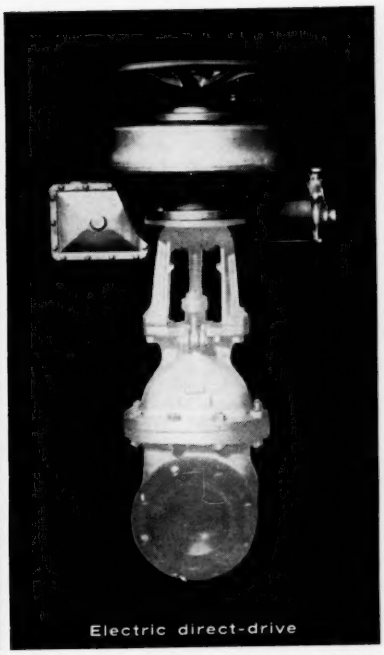

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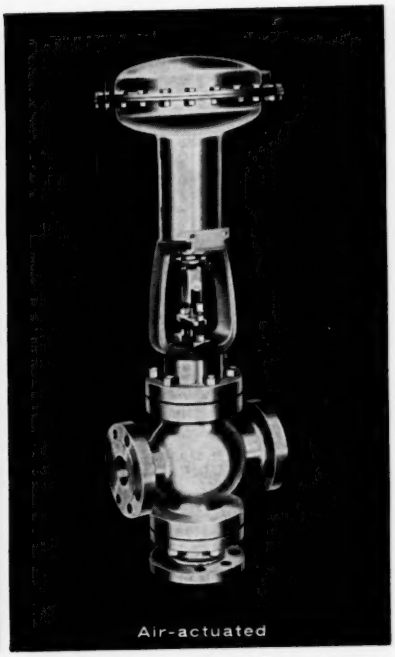

Air-actuated

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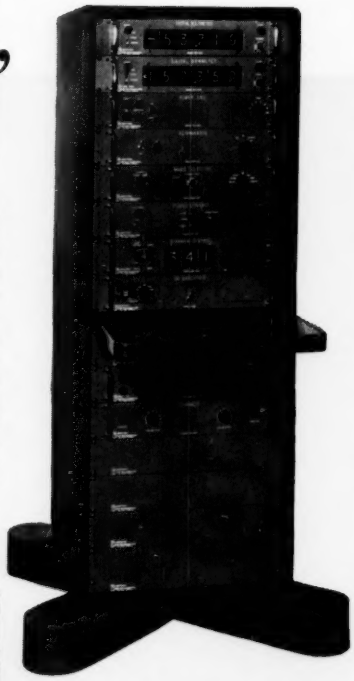
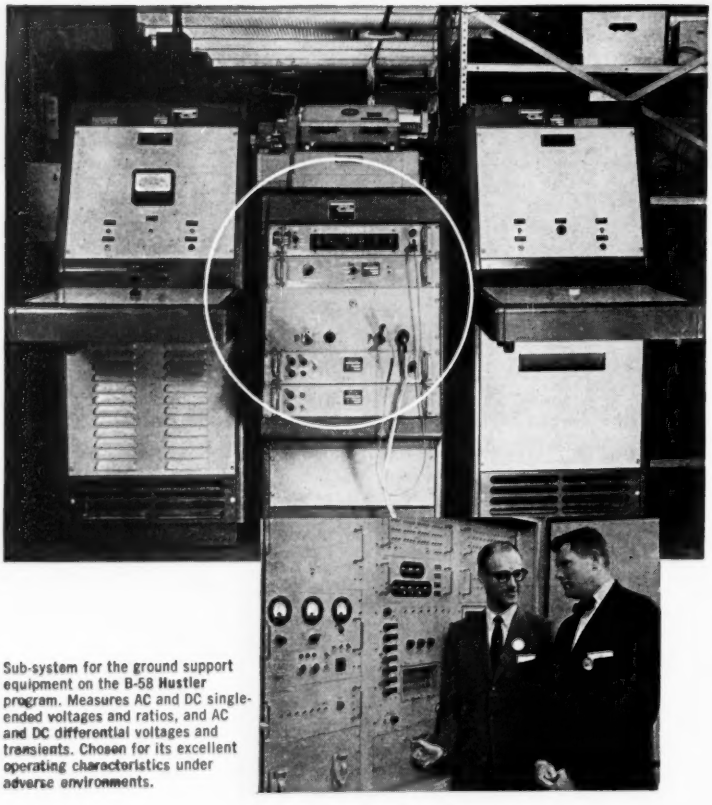
Systems shown here are typical of more than 200 designed and built by EI and now in use. They range in complexity from data logging systems for automatic scanning, measurement and recording of data from multiple transducers...to high speed, automatic checkout systems for missile and aircraft...to systems for automating industrial processes.

Because of the EI modular design approach, many of these systems can be delivered on virtually an off-the-shelf basis, eliminating the long delivery times usually associated with system development. This approach also results in a low cost system because the modules are manufactured in large quantities. Cost is almost a linear function of performance capabilities desired.

Why not talk over your digital system requirements with your EI Sales Engineer? His system experience will be a valuable help in solving your problem.



Multi-purpose digital system for measuring a variety of transistor parameters while the transistors are being subjected to environmental testing.



Digital read-out sub-system of a large, automatic, transistor production checkout system.

Sub-system for the ground support equipment on the B-58 **Hustler** program. Measures AC and DC single-ended voltages and ratios, and AC and DC differential voltages and transients. Chosen for its excellent operating characteristics under adverse environments.

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MORE VERSATILITY—AC and DC voltages, AC and DC voltage ratios, ohmic resistances, capacitance, frequency, phase, inductance, time, or combinations of these basic input quantities can be accepted by the EI system.

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MORE FLEXIBILITY—Expansion of the EI system can be made by simply adding appropriate new modules. This approach eliminates new engineering development costs each time needs change; minimizes system obsolescence.

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